MARCH 1952

Journal

VOL. 44 • NO. 3

AMERICAN WATER WORKS ASSOCIATION

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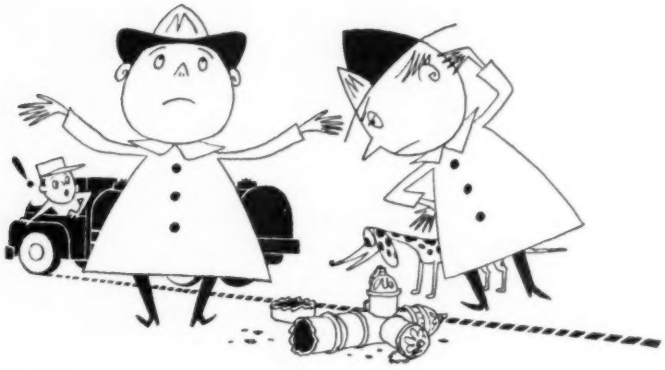
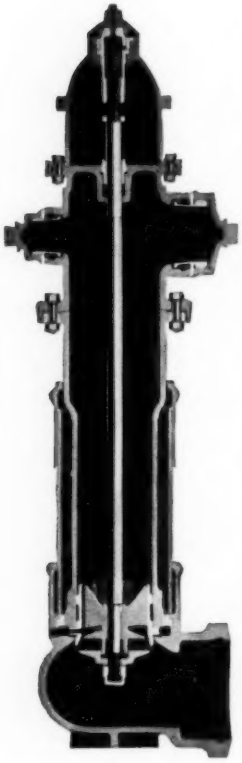
Broken hydrant cannot leak!





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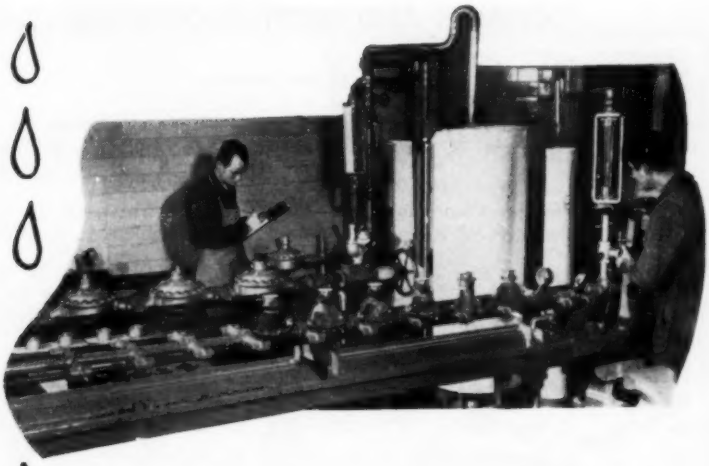

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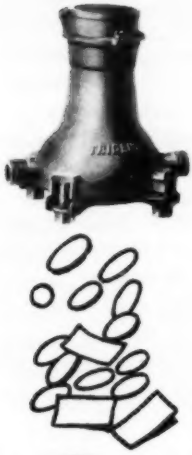

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TODAY, ACROSS THE COUNTRY—under countless city streets like the one shown above—Transite* Pressure Pipe is doing a highly efficient job of transporting water . . . often under conditions so adverse to ordinary pipe that engineers marvel at Transite's ability to stand up through the years!

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COMING MEETINGS

AWWA 1952 ANNUAL CONFERENCE
Kansas City, Mo.
May 4–9

Reservation forms have been mailed to all members, and all reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the AWWA.

Accommodations at Fourteen Hotels

All Technical Sessions and Exhibits at Municipal Auditorium

March

20—New England Section Business Meeting at Hancock Room, Hotel Statler, Boston, Mass. Secretary: G. G. Bogren, Weston & Sampson, 14 Beacon St., Boston 8, Mass.

24–26—Southeastern Section at Bon Air Hotel, Augusta, Ga. Secretary: T. A. Kolb, 89 Alexander St., Charleston, S.C.

26–28—Illinois Section at LaSalle Hotel, Chicago. Secretary: J. Leslie Hart, Western Sales Manager, U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill.

April

3–5—Arizona Section at Maricopa Inn, Mesa. Secretary: Harry S. Jordan, San. Engr., Bureau of Sanitation, State Dept. of Health, Phoenix, Ariz.

11–12—Montana Section at Northern Hotel, Billings. Secretary: Arthur W. Clarkson, Assistant Director, Div. of Sanitary Engineering, State Board of Health, Helena, Mont.

16–18—New York Section at Hotel Syracuse, Syracuse. Secretary: R. K. Blanchard, 50 W. 50 St., New York 20, N.Y.

(Continued on page 94)

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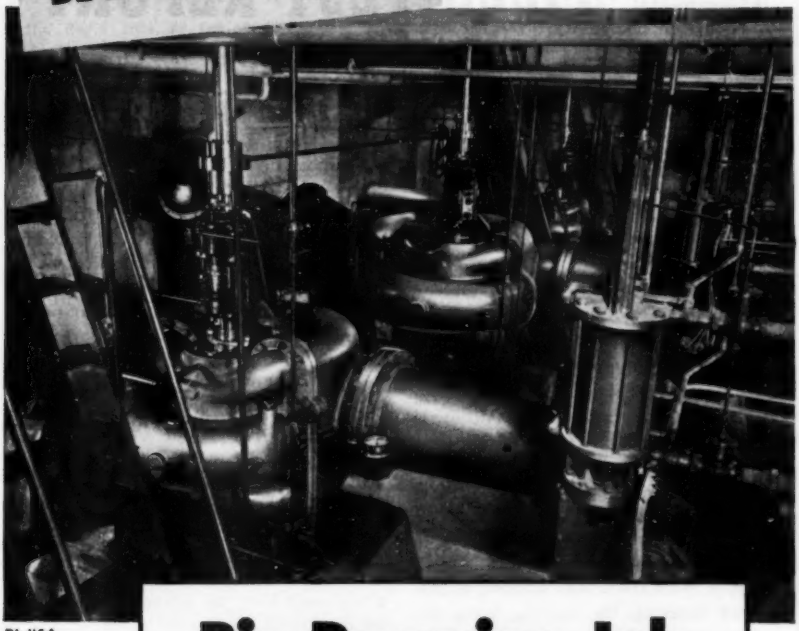

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FIELD TEST REPORT

Another Taste and Odor Problem Solved by our Aqua Nuchar Research Service

PROBLEM: Odor build-up in water in the settling basin. At a water plant using Lake Michigan water, a threshold odor survey indicated that the raw water coming into the filter plant had a threshold odor number of 2.6. After it had passed the settling basin the odor number had increased to 10. Although the odors in the raw water would not ordinarily be considered obnoxious, the build-up in odors within the settling basin made the water unpalatable.

TREATMENT: Approximately 5ppm AQUA NUCHAR was applied to the water entering the mixing basin for about 8 hours, during which a threshold odor survey showed that the intensity of the odor was not increased at the settling basin and remained the same (threshold number 2.6) throughout the plant.

The AQUA NUCHAR Activated Carbon application was discontinued after 8 hours, and subsequent examinations of the water showed that odors again started to build up after passing through the settling basin Therefore, it was concluded that more carbon would be required to completely stabilize the sludge, so AQUA NUCHAR was again fed at the same point.

This problem illustrates the necessity for running threshold odor surveys of the entire plant, thus safeguarding against conditions within the plant which may have an adverse effect on the quality of the treated water.

This type of service is offered, without cost or obligation, to any water treatment plants facing odor problems. For assistance of this type contact any of the offices listed below.

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New York Central Building 225 Park Avenue New York 17, N. Y.	Pure Oil Bldg. 35 E. Wacker Drive Chicago 1, Illinois	Lincoln-Liberty Bldg. Broad & Chestnut Sts. Philadelphia 7, Pa.	2775 East 132nd Street At Shaker Square Cleveland 20, Ohio

Journal

AMERICAN WATER WORKS ASSOCIATION

March 1952

Vol. 44 • No. 3

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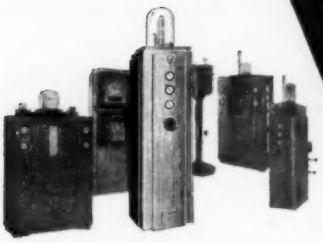
the part you don't see is important...



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For instance, the engineer, the plant operator and the taxpayer all benefit from W&T's complete line of equipment. In the selection of equipment for a water supply — large or small — the engineer can always find a W&T Chlorinator to fit all requirements. The plant operator knows that this complete line can provide a W&T Chlorinator designed to help him provide safe water with his particular plant layout. The taxpayer is assured that money spent for W&T Equipment fitted to the present as well as the future needs of his community will provide long range economy.

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 44 • MARCH 1952 • NO. 3

Keeping Ahead of Health Problems in Water Works Operation

By Mark D. Hollis

An address presented on Nov. 1, 1951, at the Chesapeake Section Meeting, Baltimore, Md., by Mark D. Hollis, Asst. Surgeon General, U.S. Public Health Service, Federal Security Agency, Washington, D.C.

IN the water works field, you have foremost on your minds problems associated with the present emergency —problems such as fixed rates and established salaries in a time of general price increases; difficulties in recruiting competent personnel in the face of military and defense industry demands; shortages of steel, of chlorine, of filter alum, and of other needed materials; and the complex problem of planning for civilian defense and disaster needs. Since it appears not to be given to our generation to live in an environment of total peace, it behooves us to think in terms of a drawn out state of emergency—an emergency that may be with us in varying degrees for from five to twenty years. During much of this period, we must plan to use for defense purposes as much as one of every five dollars' worth of goods and services produced, in our effort to guarantee world peace. This defense program has a special significance to water works people because it is putting the pressure behind the growth of American production. We take it for granted that the United States, with only 6 per cent of the world's population and only 5 per cent of its land area, accounts for roughly half of its industrial production. The physical production of goods in the United States has more than doubled since 1930. It is 50 per cent higher than it was ten years ago. We expect it to go even higher.

Increasing Demand

You are all familiar with the demands that this prodigious pace of production puts on the water works. Water is the prime raw material of

production. American producers use more water than any other commodity. Water is also the lowest priced commodity they buy.

Parallel to this rise in demand for water for production has been a rise in the demand for water for household uses by a population that has doubled since 1900. This population has increased its uses of water also with its rising standard of living—for air conditioning, automatic laundries, garbage disposal, bathing and countless other uses.

Water works engineers have done a remarkable job of anticipating and keeping ahead of these demands for water. It is reasonable to say that this nation could not have made its great record of production but for the water works profession. We could not have the millions living in our cities in healthful, hygienic surroundings but for the achievements of the water works profession. You have not only provided an ample supply of water—fundamental to our life and our economy—but, at the same time, you have worked to keep that water safe, wholesome, and palatable. The profession has been distinguished for its traditional capacity for keeping ahead of its problems—a quality of foresight and planning which is rare in any society. And the nation owes the profession an enormous debt of appreciation for the support it has given health departments and for its impetus to the public health movement. Yours has been the outstanding organized professional support for these health functions of government.

It is only a natural consequence of that tradition that you should be concerned with the eventual effects of the rise in industrial production upon water works operation. I refer in part to the effects upon ground water, of the increasing rate of withdrawals without adequate recharging. I refer also to the increasing pollution of waters by wastes of all kinds and by other by-products of our modern technology. You are aware that, despite the creditable action to control pollution, conditions have been growing worse steadily for the past fifty years. You are aware that in many communities it is no longer practical to reach out to the hills for water or to develop new ground water supplies. Frequently it has become necessary to reclaim polluted water for reuse. At Sparrows Point, Md., there is the example of Bethlehem Steel Corp., which uses for cooling purposes approximately 40 mgd of Baltimore's sewage effluent in an effort to conserve its ground water resources.

Stream Pollution

In recent years, there has been an undercurrent of disagreement with public statements about water pollution and its effects on public water supplies. Boiled down, it appears that the criticism is based upon resentment toward the implication that water pollution is affecting the efficacy of water purification. Our critics assume that, when we talk about control of pollution, we are implying inefficiency and a general breakdown in efforts to safeguard water supplies. If that is the effect on the public mind of what we say, the water works profession has a legitimate complaint, and we would do well to watch our language. But let us examine that complaint more thoroughly.

No responsible person would charge that water works in general are not

successfully coping with the present loading of streams with organic wastes. But can anyone say, looking at the facts objectively, that water works operations are on top or ahead of the task of dealing with the physiological effects of chemicals in water, both the natural chemicals and those introduced as byproducts of modern technology? This does not mean that the chemicals in water supplies today present a widespread hazard. We all know they do not. It means simply that, in keeping with our tradition of planning in advance of trouble, it is proper that we tackle these pollution problems before they result in damage. In the first place, we have to learn a great deal more than we know now about the chemicals in water and their relation to public health. We know only a little about immediate effects and the appropriate handling of phenols and similar organic compounds, phosphates, chromium, insecticides, cyanide, nitrates, sodium and other trace elements, and radioactive isotopes. We know far less about their long-run effects. We know almost nothing about their cumulative or additive effects or their synergistic effects—the effects that chemicals can achieve in combination which they may not be able to achieve separately.

All we have done so far with most forms of pollution is to learn how to live with them. As the pollution has increased, we have raised a protective wall against it, but some day that wall may have to go so high that it will not pay to build it. Moreover, it has already been demonstrated that certain chemical wastes have succeeded in coming through the wall in its present structure. At the Environmental Health Center in Cincinnati, Ohio, U.S. Public Health Service investigators have extracted a variety of complex organic chemical compounds from city water supplies. They have traced some of these chemicals to outfalls more than 300 miles upstream. Merely a few drops of some of these chemicals in as much as a million gallons of water produce powerful taste and odor nuisances and, as I say, we do not know as much as we should of the effects these chemicals may have on personal health.

We have reason to be proud of the drinking water standards, inasmuch as they represent a cooperative professional effort. But we have no right to be completely satisfied with their present form. The permissible concentrations for many toxic chemicals in water, for example, are based largely on judgment rather than on hard fact. More and better toxicological studies are needed. And I think you will all agree that, in the general field of water quality control, there is room for improvement in the techniques of laboratory controls, in the elimination of sanitary defects and health hazards, in the techniques of disinfection, and in other measures that affect the wholesomeness of water.

Federal Participation

The matters discussed above are some of the long-run problems of water works management. To say that they exist implies no criticism of water works operation. It is merely candid recognition of the continuing task of the water works operator in his honorable tradition.

Some of you, I know, are concerned about the growing interest of the federal government in the broad field of water resources development. This

concern is related to the way this interest may be felt within the water works profession. Thus far, federal legislation in your field has carefully protected the primary rights and responsibilities of the states. With intelligent management and resolute will to protect public interest, there is no reason for federal encroachment on your position. But in view of the critical importance of water to the national economy, with increasing demands upon a fixed resource, public interest will not permit responsibility for effective use of this resource to go by default. We must not fail in our respective jobs, or others may be summoned to take over.

The Public Health Service is saturated with the conviction that responsibility and authority should be decentralized to state and local officials. It does not simply make this statement. It practices this policy. Practically, the task of developing and providing water for urban and industrial uses is local, as it should be. There is some federal assistance in the development of water works in areas which have been hard hit by defense activities. In quantity, this assistance is inconsequential. It is important only because it is helping communities otherwise unable to cope with situations associated with the preparedness program.

The Public Health Service feels that it can be more useful in the field of research investigation and demonstration. The new facility in Cincinnati—the Environmental Health Center—is soon to move into expanded quarters, where it can do much more to probe into problems that lie ahead for the water works profession, to act in a sense as a reconnaissance team, and learn to use new techniques and skills which have been developed outside the water works profession. One example of a new technique for laboratory controls is the use of the membrane filter (1). In addition to its great potential in the general field of water bacteriology, the membrane filter has special significance in plans to cope with diagnostic problems of induced biological contamination. Another diagnostic technique is being developed for organic chemicals in public water supplies. These chemicals can be identified by the use of an infra-red spectrometer, a machine that has an enormous advantage in time and cost over the test-tube processes of chemical analysis. The procedure, which includes a relatively simple means of tracing the source of the chemical pollution, is but one of the many new developments in the chemistry of water which we have come to realize have a deep significance for public health as well as for the maintenance and operation of water works.

Fluoridation

Not too many years ago, it was assumed that natural water was wholly satisfactory for all uses. We have since learned that water in nature may contain troublesome chemical characteristics. This problem of chemicals in water as they affect health is complicated by the fact that the effect of a given dose may vary among individuals.

The water works engineer has been justifiably conservative about chemical treatment of drinking water in the interest of public health. Before he would add chlorine or fluorides or any other element to water, he has properly insisted on having medical and scientific authority for the action.

You are all familiar with the fact that, in May 1949, the American Water Works Association adopted a policy statement on water fluoridation which said: "In communities where a strong public demand has developed and the procedure has the full approval of the local medical and dental societies, the local and state health authorities, and others responsible for the communal health, the water departments or companies may properly participate in a program of fluoridation of the public water supply." As you know, too, this policy was reaffirmed by the Association in 1951 (*2*).

This statement is not exactly a green light for fluoridation, but it is not a red light, either. I would call it an amber light about to turn green. So far as the Public Health Service is concerned, the case for fluoridation has been scientifically established. All the pilot studies and operations have been positive. The Surgeon General has declared for the Senate Subcommittee on Health that fluoridation of public water supplies is a satisfactory procedure for reducing tooth decay by two-thirds and has the unqualified endorsement of the Public Health Service.

It may be a small point to raise here, but it is not accurate to hold that fluoridation is "mass medication." Medication means the treatment of a disease. Fluoridation does not treat cavities that have already developed. It is preventive, as chlorination is preventive. The fact that fluorides are already present normally in many drinking supplies gives point to the fact that the Public Health Service is simply endorsing the process of controlling the extent of its concentration within optimum limits. Apart from the health advantages, it is estimated that every dollar expended for controlled fluoridation will save fifty or sixty dollars worth of dental expenses. I might also say the supply of the chemicals for this purpose appears to be ample to meet the need.

Long before controlled fluoridation was introduced, the effect of fluorides on teeth was recognized and known. In natural waters, we find varying degrees of fluoride concentrations ranging from small fractions of one part per million to more than twenty parts per million. When I was practicing sanitary engineering as state engineer in North Dakota—those of us who are struggling in the red tape of Washington bureaucracy like to remember that there was a time when we were accepted professionally—I ran into examples of the physical effects of excessive amounts of fluorides in water. In several towns, the water supplies contained extremely heavy concentrations of natural fluorides—some as high as 18 ppm. A systematic study of fluorine and its effects on human beings has been going on for half a century. And that study has been followed by a number of pilot studies. Some of the states themselves have conducted pilot studies. On the basis of experience at Newburgh, the New York State Health Department has recommended fluoridation to all cities. The practice has been adopted in more than 150 cities in 24 states and it is under consideration in many more.

One of the reasons for this attention to fluoridation is that it is fairly obvious when a chemical in water affects the teeth. It is not so obvious how other chemicals in water affect the circulatory system, kidneys, liver, or stomach. Research of the future should

give a high priority to the study of these effects.

Public Opinion

I would like to express one more thought. The public awareness of the value of water is increasing noticeably. In the arid West, where water is a precious commodity, there is no doubt of public appreciation of its importance. I believe greater public awareness of the importance of water will rise also in the humid East. There should be a corresponding rise in the influence of the water works profession on public policy relating to total water resource development. I will not say whether the rise will be a result of capillary action or hydraulic pressure, but there is no doubt as to the trend. That rise will be linked to your handling of the emerging problems in water works operations. Even in ordinary times, you would want to anticipate the needs of normal growth and change. In this emergency, you have an extra incentive to keep ahead of the job. I know not only that you can do it, but that you will do it.

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State Regulation of Water Utilities

By W. F. Whitney

A paper presented on Oct. 30, 1951, at the Florida Section Meeting, Daytona Beach, Fla., by W. F. Whitney, Commissioner, Public Service Commission of Wisconsin, Madison, Wis.

THE organization, purposes, and administration of regulation of municipal and private water utilities in Wisconsin can be traced back to 1874, when a law was passed by the Wisconsin Legislature creating a three-man railroad commission, the sole duty of which was to regulate railroads. In 1876 this three-man commission was abolished and a single railroad commissioner supplanted it. Then, in 1905, the office of the commissioner was abolished and another three-man railroad commission was substituted.

In 1907 a great change was made—the Wisconsin Railroad Commission law was extended to include the regulation of all telephone, heat, light, and water utilities. These 1907 public utility and water utility laws have been copied by many states. They were the first effective utility control laws in the country. Almost every state that adopted the 1907 Wisconsin law as a guide found it necessary to exempt municipal utilities from regulation—presumably to assure adoption of the measure. At present the Wisconsin commission regulates 382 municipally owned water utilities and only fifteen privately owned ones.

In 1911 another statutory change was enacted, this one providing for regulation of the securities of public utilities, other than those of municipal organizations.

In 1915 the legislature passed Wisconsin's water-power laws. These laws applied to the regulation of 1,000 dams, the level and flow of 8,000 lakes, and 11,000 miles of navigable streams within the state. In 1927 the legislature added to the commission's duties the regulation of all common motor carriers of freight and passengers. This group currently includes 400 common motor carriers and approximately 9,000 contract motor carriers.

In 1931 the name "Railroad Commission" was changed to "Wisconsin Public Service Commission." The commission consists of three members who are appointed by the governor for staggered 6-yr terms. Under the new 1931 statutes, the 1907 laws were retained, but new and broader enforcement was provided. In 1947 new laws gave the commission jurisdiction over the introduction of natural gas in the states.

Definition of Powers

The extent of the commission's present powers and duties—affecting all kinds of public utilities—is partly stated in Chapter 196 of the Wisconsion Statutes as follows:

> The Commission is vested with power and jurisdiction to supervise and regulate every public utility in this state, and to do all things necessary and convenient in the exercise of that power.

Ever since 1907, this section has been given a broad and comprehensive interpretation. The section states the obligation of providing for a classification of service and rates; it imposes the duty to adopt reasonable rules and regulations for inspections, tests, audits, and investigations; it grants authority to inquire into management of all public utilities, to require information about ownership of stock, and to inspect utility records. This power to inquire into management has been used very sparingly. The philosophy adopted has been that the state should be concerned less with management than with mismanagement.

The statute further provides for valuation of utility property; a uniform system of accounts, audits, and inspections; certification of depreciation rates; and authorization of new construction. It requires that charges for utility service to the public be reasonable and fair; that rates and rules must not only be on file with the commission, but must be available to the public in offices of the utility at which bills are paid; and that public utilities may charge only such rates as are on file with the commission. The law requires the commission to investigate all complaints against utilities on rates, service, or service extension.

Another Law

Chapter 196 of the Wisconsin Statutes is entitled "Regulation of Public Utilities" and includes regulation of water utilities. A discussion of water-utility regulation would not be complete without reference to a portion of Chapter 66 of the statutes, which is entitled "Municipal Law." To avoid confusion, the section on municipal utilities in Chapter 66 contains a provision that nothing in it shall be construed as depriving the commission of any power conferred by Chapter 196. Some of the important water-utility provisions of Chapter 66 include methods for setting up management; assessment of benefits to abutting property when mains are laid by a municipal water utility or by a privately owned water utility that has entered into a contract with the municipality; and provisions that water bills of municipally owned water utilities may become a lien on real estate; that tax equivalents are to be paid by a municipal utility to the municipality; and that certain restrictions govern the use of funds. The statutes on municipal public utilities have never seriously interfered with exercise of the commission's jurisdiction. Regulation during the past 44 years has produced a reasonably firm policy with definite procedures developed from early experience by trial and error. The purposes of regulation and mechanics of administration have been carefully tested. The end result is believed to be a type of regulation that is satisfactory to water utilities, the public and the commission.

Purposes of Regulation

Some of the purposes that have evolved through the years for regulating water utilities in Wisconsin are:

1. To assist in promotion of adequate service
2. To establish reasonable rates for water service
3. To eliminate free service and discrimination
4. To maintain a uniform system of utility accounts
5. To provide for utility-property valuation
6. To investigate customer complaints

7. To grant authority to utilities to transact business and to extend service when public convenience and necessity demand such authorization.

In promoting adequate service, the commission fixes standards for measurement of water pressure; it prescribes reasonable regulations for wells, pumps, water transmission, and service; it translates into performance the adequate-service objective of water-utility regulation.

Water rates filed with the Railroad Commission in 1907 disclosed wide variations of rate levels, service classifications and kinds of rate schedule. Many schedules were regressive—that is, the decreases in rates with increased consumption were applied uniformly to all the water used, and not just to the additional increments. Such regressive schedules, which encouraged consumers to waste water, have long since been stricken from the active records.

Throughout the years, general-service rates have developed from an early unmetered rate into the two-part metered rate commonly used today. The two-part rate consists, first, of a minimum bill which includes a service charge and, second, of a block schedule to cover water used.

The establishment of rates that are reasonable can be illustrated by a comparison. From 1940 to 1950, weekly wages in Wisconsin industries increased 126 per cent; food prices, 127 per cent; and general cost of living, 80 per cent. Water rates within the state, however, increased only 12 per cent. The Public Service Commission of Wisconsin has attempted to effect adjustments to benefit both the customers and the water utilities. Its goal of reasonable and just rates has maintained them at a low level, consistent with provision of good service to the public and of a fair return to the utility.

Fire Protection Service

Considerable confusion and fundamental disagreement have arisen not only on the cost of furnishing fire protection service, but on the question of who should pay for it. Charges in 1907 for public fire protection service either were not levied or were much less than the cost of providing the service. In many jurisdictions outside Wisconsin, public fire protection is still furnished without charge to property owners—the entire cost of the service being borne by the other utility customers. During recent years a more equitable distribution of this cost has been developed.

Fire protection service rates were originally called hydrant rentals and a fixed annual rate was charged for each hydrant. In Wisconsin, this practice was replaced by the rate now used which consists of a fixed annual amount paid for availability and use of facilities existing at the time the rate was determined, with provision for adjustment as facilities are added. For comparison among cities of varying populations, the rate for public fire protection service is frequently reduced to the per capita amount. For example, the 1951 per capita charges for public fire protection in Wisconsin will vary from approximately $1.00 per yr in the larger cities (exclusive of Milwaukee) to as much as $5.00 per yr in a few small villages. The average per capita charge is approximately $2.00 per yr. Fire protection revenues are a more important part of total revenues than they were before regualtion of water utilities, and they are a much more important factor now than

during the early days of regulation. This situation is due partly to improved methods of determining and assigning service costs, and partly to increased fixed charges, which costs influence public fire protection service charges more than do variable expenses. Municipalities should not receive free water service—they should pay for the water they use.

Another purpose of regulation has been to enforce the statute that forbids utilities to furnish free service. Wisconsin supreme court decisions * make it clear that a municipality operating a water public utility does so in its proprietary capacity and not as a governmental agency. The municipal corporation must therefore pay for whatever actual service it receives, such as street flushing, sewer flushing, and the supply to drinking fountains, city parks, cemeteries, schools, the city hall or other city buildings.

Commission's General Orders

The purposes of regulation depend upon specific statutes in Chapter 196. In addition, two general orders have been issued by the commission to supplement the statutes. Early experiences resulted in public hearings in 1918 on water service standards. At that time tentative standards were designed, and comments by the utilities were requested. As a result, General Order U–1288 for standards of water service was issued on October 30, 1920 (*see* Appendix A, p. 182). In 1933 the commission issued General Order 2–U–637 on the construction and extension of water supply systems (*see* Appendix B, p. 185).

* *State Journal Printing Co.* v. *City of Madison*, Wis. 148, 396–403; *Pabst* v. *City of Milwaukee*, Wis. 196, 522.

Administration of Laws

In the operation and administration of the utility regulatory laws, the commissioners determine all matters of policy affecting regulation of water utilities. The existing policy on the definition of a reasonable rate base is one computed on original cost less accrued depreciation. A reasonable return for water utilities has usually been fixed at approximately 5.5 per cent on the rate base. Service areas of municipal utilities may be limited to the municipality or may include a well defined area added to the municipality. If a dispute arises because of an extension of service, the commission studies the facts, past practices of the utility, reasonableness of the request for service, and laws that apply, before rendering its decision.

Funds to carry on the public-utility work of the commission are obtained from assessments against utilities. When an investigation of a particular utility is considered necessary, the cost is assessed directly on the utility or utilities involved. The amount so assessed in any calendar year, however, may not exceed 0.8 per cent of gross revenues for the preceding year. Commission costs not charged directly to the utility are met by proceeds from a remainder assessment against all utilities. This may not exceed 0.2 per cent of gross revenues for the previous year.

As mentioned before, municipal-utility securities are not subject to commission regulation. Privately owned water utilities in Wisconsin must secure approval of all securities before the securities are issued. Equity capital of more than 50 per cent is usually required by the commission for bond issues or other borrowing by private

water utilities. A ratio of 55 per cent equity to 45 per cent debt is considered desirable.

Rate Work

The commission's rate work with water utilities is proportionally greater than that with other public utilities, because the preliminary inspection of engineering plans is performed by the state board of health. Upward rate revisions may be made only after a public hearing. The rate application form is comparatively simple. It requires a brief statement of the reason for seeking the increase and the proposed rate schedules. Many water utilities—instead of applying for a specific schedule of rates—request rates they may consider adequate and reasonable. They may ask for a specified annual increase in revenues or for rates that provide a maximum return on the rate base. A downward revision of rates may be made, without a hearing following commission approval and the filing of the revised schedules with the commission.

The commission maintains a complete file of rate matters for each water utility and, in addition, maintains a compilation of current rules and rates.

When a change in rates or rules is authorized, revised rate sheets are prepared by the commission, and a copy of the official rate file is sent to the utility. Exceptions to this procedure are made with very large utilities, which submit proposed changes in rough draft form. After approval is obtained, copies of revised rate sheets are prepared according to commission specifications and are furnished to the commission. This latter procedure is followed with larger utilities because they maintain several offices and usually prepare mimeographed rate sheets for their own use. Additional copies, therefore, are reproduced with a minimum of expense.

Complaints

When a specific complaint is lodged against a water utility, the first step is to determine whether the matter is within the commission's jurisdiction. If it is, the usual procedure is to open an informal investigation, which may consist of a request for information from the utility, or a commission employee may visit the utility. Suggestions for settling the complaint usually follow, and if they are accepted by both parties, the matter is closed. If no agreement is reached informally, a public hearing is held. After consideration of all evidence, the commission issues an order. If the complaint is found to be unreasonable, it is dismissed. All commission orders are subject to appeal and review by the appellate courts and the Wisconsin Supreme Court.

The commission employs staff service inspectors who make routine inspections as frequently as their work schedules permit. Inspection of water utilities includes a check of pressure, substation meters, metering procedure, meter-testing equipment, maintenance of required records, operating efficiency, and flushing practices.

Benefits

Any system of state regulation of water utilities affords definite benefits to the public and to the regulated utilities. When Governor Heil appointed the author to the Wisconsin Public Service Commission in 1939, he said, "Never forget your duty always to be fair—not only fair to the public, but also fair to the utiliites which serve that public and are under regulation

by the Wisconsin Commission." That philosophy has been the constant standard of the commission.

The commission and its staff frequently advise and give assistance to the water utilities. Utility managers, superintendents and other interested individuals or groups discuss with the commission problems related particularly to proposed additions to the plant. The staff is always available as a source of information. The commission becomes a clearing house for these exchanges of thinking and pertinent data. Similar discussions also take place when water utilities require additional revenues. They discuss their financial problems and obtain advice on remedying them. Commission accountants are available to assist with such work. When a preliminary accounting investigation is requested or is ordered by the commission, extensive studies are made of the utility's accounting practices, and recommendations are offered. In such investigations, the necessary adjusting entries would be suggested by the commission. The commission also certifies depreciation rates to be used by utilities and reviews such rates periodically

Water utilities frequently refer complaints to the commission, or obtain ideas for settling disputes before a formal complaint is made. Suggestions to utility officials often result in the clarification of interpretation of rules, statutes, and facts. Good customer relations are thereby produced by a simple application of the Golden Rule.

Staff personnel and commissioners are constantly being astonished by the favorable reaction of public utilities to regulation—especially the friendly reception by the state's 382 municipally owned water utilities. Not a single exception is known.

APPENDIX A

General Order U–1288

Opinion and decision of the commision on investigation, on motion of the commission, into standards of water service in the state of Wisconsin. Rules regulating the standards of water service for water utilities throughout the state were established by the commission on Oct. 30, 1920, in accordance with Section 1797m–23, Wisconsin Statutes.

Water Utilities, Standards of Service, Jurisdiction of Commission, Quality of Water

The quality of water supply, sewage disposal, and allied matters, have been placed under the jurisdiction of the State Board of Health by Sections 1407m–1 to 1407m–4, Wisconsin Statutes, and, in order to avoid unnecessary duplication, the Commission will not prescribe rules governing these matters.

The Wisconsin Public Utilities Law (Section 1797m–23) requires that the Commission shall establish standards of adequate service for public utilities.

In pursuance thereof, the Commission issued notice of investigation and notice of hearing, as prescribed by law, relative to standards for water service, this hearing having been scheduled for, and held on, May 31, 1918, in the Capitol at Madison.

Representatives of a considerable number of the water utilities of the state were present, as were also the Secretary, and others, of the State Board of Health.

As a basis for discussion in the hearing, a set of tentative rules was published with the notice of investigation. These originally proposed rules have been carefully reconsidered in the light of all the comments made upon them, and in view, also, of subsequent changes made in the Statutes by the Laws of 1919.

Chapter 447, Laws of 1919 (Sections 1407m–1 to 1407m–4 of the Statutes), definitely places the matter of supervision of quality of public water supplies, as well as sewage disposal and allied matters, under the jurisdiction of the State Board of Health. Any attempt on the part of this Commission to prescribe and enforce rules having to do with quality of water furnished by utilities, would be wasteful duplication. Some of the rules originally proposed are, therefore, omitted entirely.

The proper and reasonable rules and regulations governing the furnishing of public water utility service in Wisconsin are deemed to be as follows:

1. *Quality.* Water furnished by any water utility shall be of such quality as will have the approval, or comply with the requirements, of the State Board of Health.

2. *Protection.* Public water supplies within the distributing-pipe systems shall be adequately protected against pollution through cross connections with other systems having primary or auxiliary water supplies taken from polluted sources. They shall also be adequately protected against any unnecessary and avoidable pollution at their own sources, and at all times after being taken therefrom, until delivered to consumers.

3. *Flushing mains.* Dead-ended mains, or other portions of distributing systems, shall be flushed at sufficiently frequent periods as to eliminate or minimize complaints from consumers arising from a foul or offensive condition of water due to stagnation. Proper provision must be made for flushing all parts of a system which need flushing.

4. *Records of flushings.* Records shall be kept of all flushing of mains, showing date, place and duration, and such records used as a guide, so far as they may be such, in determining the necessary frequency of flushing of the same mains thereafter, in order to avoid well-founded complaints from consumers.

5. *Complaints.* Records, properly classified, shall be kept of all complaints received from consumers relative to character of service, low pressure, bad water, unusually high bills, or other matters, together with the disposition of, or remedy provided for, each complaint, if any, together with dates of complaint, and shall be otherwise complete and explicit.

6. *Pressure.* Every water utility shall at all times maintain, in all parts of its distributing system, pipe of ample capacity and water under pressure sufficient to meet the reasonable requirements of the consumers dependent thereon for their supplies of water, including the necessarily involved losses of pressure in service connections.

7. *Pressure records.* Every water utility in cities of more than 5,000 population, shall maintain in service at least one correct and accurate pressure-recording gage, pipe-connected independently to some part of its distributing system, whereby graphic records of the water pressure in such part of the system, continuous for each consecutive 24-hr period, shall be automatically made. Such records shall show the time and date of both beginning and ending, and shall be preserved on file in the office of the utility for a period of not less than 3 yr following their respective dates.

8. *Fire service.* Each water utility furnishing fire protection, as well as domestic and industrial, service, shall, unless exempted by the Commission from the necessity of furnishing fire streams direct from hydrants, be prepared on short notice to make such increase in the normal pressure and volume of water delivered as may be required for reasonably adequate fire protection and other simultaneous service throughout the system.

9. *Pumpage records.* A permanent record shall be kept of the amount of water pumped into the distributing-pipe system each day, and the amounts pumped daily shall be summarized by months, and such daily records and summaries kept on file.

For measuring pumpage, station meters are recommended as much more reliable and satisfactory than the simple pump stroke, or revolution, counter.

10. *Initial accuracy of meters.* Before initial installation, every new meter shall be tested by the utility for accuracy of registration, and no meter whose accuracy of registration does not fall within the following limits of allowable error shall be placed in service.

Meter Size *in.*	Allowable Error ±2 Per Cent on Flows of: *gpm*	Allowable Error −10 Per Cent on Flows of: *gpm*
$\frac{5}{8}$	1–20	$\frac{1}{4}$
$\frac{3}{4}$	2–35	$\frac{1}{2}$
1	3–60	$\frac{3}{4}$
$1\frac{1}{2}$	5–100	$1\frac{1}{2}$
2	8–160	2
3	16–320	4
4	28–560	7
6	48–960	12

11. *Maintenance of accuracy.* The accuracy of registration of all meters in service shall be maintained, and shall be insured, by periodic retests of such frequency as the conditions of service in any case may warrant. Retests should include a test on a small and definite rate of flow within the range for which the allowable error is 2 per cent.

12. *Complaint tests.* Every water consumer or utility patron shall be entitled to have his meter retested by the utility at any time upon his conditional deposit of $1 per in. of nominal size or fraction thereof, and such deposit shall be returned to him by the utility in case the retest shall show the meter to be overregistering by more than 2 per cent; otherwise, it shall be forfeited to the utility by the depositor. Such retest on request of a consumer shall be made in his presence, if desired by him.

13. *Referee tests.* Any water consumer may have an official test of his meter made by this Commission upon request, accompanied by a deposit of a meter-test fee of $2 per in. of nominal size or fraction thereof, and upon payment of meter-transportation expense, if any. In such case, the meter-test fee deposited by the consumer will be refunded to him by the utility furnishing the metered service in question if the meter be found by the Commission to be overregistering beyond the allowable limit of error for new meter as stated in rule 10.

14. *Meter records.* A permanent record shall be kept of the tests on each meter, and such records shall show the name, number, and size of the meter; date and place of the original and of each subsequent installation; and the complete results of each test and retest. The records shall also show the cause of each removal from service and what, if any, repairs were made between time of removal and the retest of the meter. The original test record shall show the identification of the meter and all data taken, in form that permits convenient checking of the methods employed and the calculations. Any meter that has been in service for a period of 2 years, for which no satisfactory record is available, shall be tested, and a permanent record made within 1 year from the date of this order, unless this time is extended by written order of the Railroad Commission.

15. *Equipment.* Each water utility furnishing service to any of its patrons on the meter basis shall provide and maintain suitable working space and equipment or apparatus satisfactory to the Commission for the testing and repairing of meters. Meter-testing equipment shall at all reasonable hours be accessible for inspection and use by the authorized representatives of the Commission.

16. *Portable test meters.* Where portable test meters are used to determine the accuracy of meters in service, they shall be frequently recalibrated by suitable testing apparatus to insure safe reliance upon them for correct registration at the specified test rates of flow.

17. *Billing.* Bills rendered periodically for metered water service shall designate the readings of the meter at the beginning and end of the interval for which the bill is rendered, and shall give the dates of the readings of the meter.

18. *Construction records.* Every water utility shall prepare, or cause to be prepared, and shall keep on file, permanent and adequate records, in the form of maps or clearly descriptive tabular statements, or both, showing the size, kind, and location of all its underground main and service pipelines or other hidden construction; and definite locations of all valves and shutoff cocks. For all new construction work done after January 1, 1920, the records shall also show date of construction, by year and month.

APPENDIX B

General Order 2-U-637

General order governing construction of mains, wells, pumping plants, purification plants, and storage reservoirs by public water utilities. Rules regulating the standards of equipment for water utilities were established by the commission on Oct. 19, 1933, in accordance with Section 196.48 of the Wisconsin Statutes.

Rule 1—Transmission and Distribution Mains

Unless and until the Commission has issued a certificate of authorization therefor, no water utility shall construct, acquire, or place in operation any main for the transmission and/or distribution of water for public use in any municipality in which said utility is not legally operating as the only water utility therein at the time of the proposed construction.

Rule 2—Wells, Pumping Plants, Purification Plants, Storage Reservoirs

Unless and until the Commission has issued a certificate of authorization therefor, no water utility shall construct or place in operation any new well, pumping plant, purification plant, or storage reservoir.

Rule 3—Submission of Information

Each water utility shall advise the Commission 30 days (unless the Commission shall allow a shorter period) before making expenditures on the following class of projects:

1. *Transmission and distribution mains.* Any installation, construction, replacement, extension, or acquisition of mains in any municipality in which said utility is legally operating as the only water utility therein, which is estimated to involve gross property additions in excess of 25 per cent of the existing investment in the corresponding class of plant in the same municipality, or in excess of $10,000, whichever is the smaller, provided that advice need not be given of any project of less than $500.

2. *Additions to pumping plants and purification plants.* Any installation, construction, replacement, or acquisition of additional units in present plants which is estimated to involve gross property additions in excess of 25 per cent of the existing investment in the corresponding class of plant in the same municipality, or in excess of $10,000, whichever is the smaller, provided that advice need not be given of any project of less than $500.

Rule 4—Character of Notice

The advice to the Commission referred to in Rule 3 shall include a brief descrip-

tion of each project, an estimate of the gross cost and of the net increase in investment, a brief statement of the reasons for such construction, etc., and such other information as the Commission may hereafter call for. If any company prepares an annual budget or comprehensive plan for future work, the filing of a statement of such budget or plan containing the information specified above will usually constitute sufficient advice as to all projects included therein. The Commission reserves the right to require a certificate of authorization for any of the work proposed under Rule 3 when it believes such authorization to be in the public interest.

Rule 5—Definitions

1. The term "water utility" as used in this general order means and embraces every corporation, company, individual, association, their lessees, trustees, or receivers appointed by any court, and every town, village, or city that may own, operate, manage, or control any plant or equipment within the State for the pumping, purification, storing, transmission, distribution, delivery, and/or furnishing of water for public use directly or indirectly to or for the public.

2. The term "municipality" means any town, village, or city.

3. The terms "main" or "mains" shall mean any pipe, conduit, or other conveyance through which water for public use may be transmitted or distributed. It shall include trenches or other structures in or upon which such pipe, conduit, or other conveyance is carried, and also land, easements, or other rights of occupancy or use requisite for the construction and operation of such pipe, conduit, or other conveyance.

4. The term "gross property additions" means the total cost of new material or equipment and the labor of installation thereof.

5. The term "net increase in investment" means gross property addition less the net retirement of material or equipment removed from service. (Net retirement means gross retirement less salvage value.)

6. The term "acquisition" as used herein refers only to the acquisition of a unit of plant in place and ready for operation and does not include the purchase of materials or equipment for later installation.

Rule 6—Conditions in Orders

The Commission, in the issuance of certificates of authorization as contemplated by this order, may find it in the public interest that such certificates be issued upon conditions. Any certificates thus issued subject to condition must be accepted with the condition as attached.

If any utility deems the conditions imposed in the certificate to be unreasonable, illegal, or improper, its remedy is to request a hearing or rehearing at which such objections may be pointed out, and, if the objectionable features are not stricken out by the Commission, then an appeal should be taken.

Rule 7—Procedure

An application for a certificate of authorization as contemplated by this order shall be filed with the Secretary of the Commission in triplicate, and shall set out such information as will convey a full understanding of the circumstances surrounding, and the reasons justifying, the proposed acquisition, construction, or extension. The Commission reserves the right to call for such additional information as it may deem necessary.

Rule 8—Effective Date

This general order shall apply to all mains, plants, and reservoirs on which construction work is begun on or after October 20, 1933.

Timekeeping—An Administrative Tool

By James W. Franklin

A paper presented on Oct. 25, 1951, at the California Section Meeting, San Francisco, Calif., by James W. Franklin, Chief Timekeeper, Dept. of Water and Power, Los Angeles, Calif.

MOST people occasionally find it necessary to stop and take stock of themselves and their activities to determine the purpose of those activities and, in comparison with some standard, to make an honest appraisal of actual personal performance. This self-analysis is nearly always enlightening although sometimes painful. It is equally necessary for individuals in the utility field to stop from time to time to give serious consideration to the purposes of many phases of their activities and to evaluate the progress toward the attainment of objectives. Although such analysis and evaluation is desirable in practically all aspects of work, processes that have been significantly changed should be given particular attention. Utility timekeeping and payroll procedures stand out boldly as functions that, because of the demands placed upon them, have changed both objectively and procedurally.

Index of the Past

Of interest is the speculation that, in the absence of all other records of a particular era, reconstruction of its economic and social trends would be entirely feasible simply by analyzing the payroll records of selected representative industries. An analysis of this sort would produce data on wage and salary standards that prevailed during the particular period, and this information, when added to the knowledge gained of salary fluctuations in the various labor classifications, would constitute a valuable index to the economics of the period.

An analysis of payroll records of the past 10 to 15 years, for example, would disclose many important facts. Salary increases in certain job classifications would point to the scarcity of labor in those classifications or to the presence of various forms of collective bargaining. Blanket increases for all levels would indicate cost-of-living increases, increased taxes, and many other factors.

Study of time and payroll records would produce evidence of material changes in socal tendencies and in employer-employee relationships. Evidence of such changes would be the liberalization of vacation policies, social security programs, employee retirement and disability plans, and many other aspects of employment conditions.

Period of Change

During the past 10 to 15 years, more social changes actually have been effected than at any time since the development of the modern form of utility organization, and there is no rea-

son to assume that the period of change is over—that current conditions and demands will be maintained. On the contrary, there is every indication that, in the future, more demands, both objective and procedural, will be made for change in payroll practices. Failure to appraise current and past activities critically, therefore, would be an unwise policy indeed. If objectivity and methods of procedure are weak and insecure, these foundations must be strengthened before additions are made to the structure.

Appropriate for discussion at this stage is the potential effectiveness of the timekeeping and payroll function in the modern utility organization and the manner in which a well organized and effective procedure can operate as an administrative tool. In addition, a few of the factors that can produce such a valuable tool may be reviewed.

Primary Function

The primary function of timekeeping and payroll procedure, of course, is to pay employees accurately and on time. Not many years ago, this basic function was practically the only one given recognition. A payroll procedure that fails to perform this fundamental requirement necessarily produces a number of serious and undesirable consequences.

If the check received by the employee is greater than his true earnings, the utility obviously suffers a direct loss, which is generally not recoverable as overpayments are seldom reported, and their detection through normal auditing procedure is rarely accomplished. The short check, however, presents quite a different situation. The utility normally does not have to resort to payroll auditing to detect this situation—the short-changed employee is sufficiently articulate.

The utility sustains a serious loss whether, immediately after an investigation, the employee is paid the difference, or whether his claim is approved only after presentation of a grievance, the solution of which requires legal opinions, union intervention, and management determination. The measurable part of the time lost is that consumed by presentation and consideration of the claim. Less easily measured is the time lost while the employee discusses and rediscusses his plight with his fellow workers. And completely incalculable is the loss of prestige suffered by the utility and its management. This loss of prestige affects all levels of management.

Few, if any, features of employment are regarded as highly as is the paycheck. In the minds of most employees, it is a physical manifestation of the management of the utility for which they work. An employee cannot respect an employer who tolerates laxity in administrating payroll procedure that the employer himself has established or accepted. The end result of such laxity is failure to produce a correct paycheck at the appointed time. Failure to give adequate recognition to the effects of the short or late paycheck on employee morale and on performance is simply an evasion of facts.

Aid to Benefit Programs

Another aspect of the timekeeping process can furnish a valuable aid to administration. A modern trend has been toward increased benefits and privileges to employees. The granting of such privileges, almost completely unknown a short time ago, is a far-

sighted management policy, as well as a definite trend in the current social pattern. The granting of certain privileges, in the form of time allowances with pay for defined reasons, discourages deceit by employees and reduces the extension of special privileges to favored workers.

At present most utilities extend such privileges as: paid vacations and paid leaves for voting, sickness, disability, preventive medical or dental treatment, and death or illness in the immediate family. If such a policy exists, management must be able to evaluate the extent and frequency of these allowances. Such evaluation is absolutely necessary to determine the costs involved. With this knowledge, management can extend or curtail time allowances in accordance with good, realistic business practice. The availability of this pertinent information rests on two basic requirements. The first of these is that the time card or other recording document always report the time-off and time-worked situation accurately. The recording medium must report honestly the extent of, and reason for, any absence from work. The second requirement is that all reasons for which an employee might be absent with pay be codified for identification purposes and that these reasons be so reflected in official timeroll records. With this information, management can determine tendencies toward abuse of all or particular privileges either by the organization as a whole, or by particular individuals.

Labor Distribution Function

The more important requirements of good timekeeping practice that affect both the utility and the employee in varying degrees have been discussed. One aspect of timekeeping that primarily affects the utility, however, is that of labor distribution. Distribution of labor is sometimes considered a by-product of the timekeeping function. Such designation can be dangerous, however, as it implies that the two functions, although closely related in actual performance, are not of equal importance. Few, if any, functions can compare in importance with preparation of labor distribution. In the utility field, it is difficult to estimate the proportionate cost of payroll labor to overall costs. The source of supply, territory served, and many other factors make generalization unrealistic. It is conservative to assume, however, that, in the utility field, payroll labor absorbs a large portion of each revenue dollar. This proportion varies but is at least 35 per cent of revenue.

Many factors influence and demonstrate the need for factual cost information. Although, in the utility field, the factor of competition is not as important as it is in industries to which knowledge of production cost is essential to avoid failure, it is nevertheless indispensable to know the cost of the product that is being sold. Accurate costs are necessary in determining the adequacy of the rate structure, in planning additions and improvements to the water works system, and in making arrangements for adequate financing.

Good Practice

A number of factors contribute to the realization of the established standards of timekeeping and payroll practice. In these considerations, of course, there arises a temptation to digress into an endless maze of needless discussion of the various types of timekeeping forms, the advantages and

disadvantages of centralized and decentralized timekeeping, and similar aspects of technique and practice.

The author believes that no ready-made timekeeping procedure that can be expected to fulfill the needs of all utilities exists. Significant differences in the scale and kind of operation, organizational structure, and allied factors clearly indicate that the most efficient timekeeping system is one that is tailor-made to fit individual needs. With but few exceptions, however, it should not be necessary to obtain outside assistance when installing a new timekeeping system or when modernizing an existing one. If properly applied to the development of a procedure, the employees' intimate knowledge of the problems and requirements of a utility will produce results that are as good as, if not better than, those resulting from a comparatively superficial study by outside consultants.

Timekeeping Personnel

Regardless of the approach to, or the actual technique of timekeeping, there are certain fundamental concepts that should receive serious consideration. As in any similar process, the factor of adequate personnel is paramount. The ultimate design of forms, procedural manuals, and other devices are valueless without the right kind of personnel to use them.

The complexities of modern timekeeping and payroll practices and the importance attached to their proper performance have led to the establishment of a separate branch of accounting which is studied by individuals who are destined to control and direct the timekeeping and payroll functions of large-scale enterprise. The utmost care must be exercised, therefore, in selecting the balance of the timekeeping staff. Personnel who have the ability to perform repetitive work meticulously, and who have the maturity of judgment required to understand and apply the complex rules and conditions of employment, should be selected.

Regulations

It is of the greatest importance that rules and conditions of employment be set down in written form. Although such a statement may seem trite, many organizations still promulgate regulations by word of mouth.

Differences of opinion exist on the relative advantages of supervision by rule as opposed to the more personalized approach that was used in the past. Regardless of personal viewpoints, however, the increasing size of utility organizations and the overall necessity for consistent policy have demonstrated the desirability of written regulations. Adherence to these rules will result in uniformity of supervision. Examination of the grievance records and of the underlying causes of these grievances in any large, modern utility will often disclose an ill-considered, although well intentioned, action by a supervisor who attempted to settle a situation arbitrarily. The need for and close adherence to regulations that are clearly stated and rigidly and impartially applied throughout the organization is therefore clearly indicated.

Employment rules need not be presented in legal form; in fact, the use of ordinary, clear language is desirable. They also need not attempt to establish solutions for every conceivable situation. The author's experience has

proved the fallacy of striving toward such a utopian situation. The regulations need only reflect clearly the intent and purposes involved. The occasional, isolated problem that is not precisely covered by rule may generally be considered and resolved in a manner acceptable to both employer and employee. Of much greater importance is consistency in interpretation of rules throughout the entire utility organization.

Indoctrination of Supervisors

Supervisors at all levels should be indoctrinated with the importance of the timekeeping function and their responsibility for it. It is quite inconsistent for a superintendent who is most prudent and economical in purchasing materials and supplies to approve timerolls that involve much larger expenditures than all his other functions, without the slightest interest in the facts they disclose and without exercising the same degree of control that he does over other expenditures. A realistic indoctrination course and continued interest and emphasis on it by top management will bring into sharper focus the obligations and responsibilities of supervisors at all levels.

A Simple Check

Efficiency in timekeeping and payroll procedure requires continuous attention from utility management. A simple and efficient device to achieve this end is a periodic report that enumerates in detail all adjustments of payments. A report of this sort should give the employee's name, his supervisor, the amount of money involved in the adjustment, and a summary description of the facts that occasioned it. Analysis by top management of these reports will reveal the presence and extent of various errors and will indicate poor administration, misunderstanding, or misapplication of rules, as well as other factors that contribute to poor practice and poor results. Without such reports, extremely unfavorable conditions, that would otherwise receive immediate correction, can continue.

It is reasonable to assume that a payroll that requires corrections for short payments contains an equal number of overpayments that would require adjustment if reported or detected.

Labor Distribution Implementation

An earlier part of this discussion directed attention to the need for data on the various expenses of utility operation and stated that payroll labor charges constituted the largest single item of repetitive cost. Labor distribution practice, the process that makes these vital cost data available, warrants serious consideration.

Several more or less closely related factors undoubtedly contribute to the success or failure of labor distribution practice. Some individuals evaluate the soundness of labor distribution practice on the basis of the adequacy of labor distribution rates. The application of these rates to the hours charged to the various accounts and work orders will equal the amount of the payroll. The technique involved in establishing adequate distribution rates and subsequently adjusting them as required, is a vital element. This process is purely arithmetical, however, and its soundness should obviously be axiomatic. The author, however, approaches the soundness of labor dis-

tribution practice more directly—from the validity of the selection of the account to be charged. This basic selection is the foundation upon which the entire labor cost structure rests. It is an element, however, which seldom seems to receive the attention and scrutiny that it deserves.

Too few foremen and other supervisory personnel whose responsibility it is to distribute labor appreciate properly the importance of this phase of their work. Too often such employees adopt a completely frivolous attitude and attempt self-detachment from this problem, as they erroneously assume that such matters concern clerical personnel. If such conditions prevail, an education program that emphasizes the importance of this responsibility and the attitude that management takes toward its unsatisfactory performance should be instituted.

Charging labor to the appropriate account requires the active cooperation of everyone concerned. It requires a sound basic knowledge of the purpose of the accounts and continuous inquiry to determine whether misconceptions of the intent of the accounts and the appropriateness of labor charges are permitted to distort cost figures. Although, in spot checking labor charges, auditors may exercise a salutary effect, their lack of familiarity with operating processes often precludes their effectiveness. The basic responsibility must be vested in the personnel who have primary familiarity with the nature of the work performed.

Summary

A few of the more important potentialities of good timekeeping and labor distribution practice have been reviewed. Reference has been made to the inevitable results of unsound and outmoded practice. The facts elicited can readily be utilized in the personal self-analysis suggested at the outset of this discussion.

The second aspect of the analysis obviously rests with the individual, for he alone best knows his personal shortcomings. Each utility, therefore, is strongly urged to analyze its own timekeeping and payroll practices critically, in order to determine whether these practices are currently producing the required results and whether they are in accordance with sound business practices.

Mortality Experience With Illinois Municipal Wells

By H. E. Hudson Jr. and J. L. Geils

A paper presented on May 2, 1951, at the Annual Conference, Miami, by H. E. Hudson Jr., Head, and J. L. Geils, Assoc. Engr., both of the Eng. Subdiv., State Water Survey, Dept. of Registration and Education, Urbana, Ill.

DURING the past seventy years, use of ground water in Illinois has developed on an immense scale, but this rapid expansion was not accompanied by close technical examination until the last fifteen. Although the Illinois State Water Survey has been collecting information on ground water developments since 1895, many aspects of this work have not been comprehensively reviewed. The beginnings of such a review were made by J. B. Millis and H. E. Romine in 1946 and summarized in a panel discussion which was published in the JOURNAL (1). An AWWA committee previously gathered mortality data on water works components and published this information in *Survival and Retirement Experience With Water Works Facilities* (2). The methods used in that publication have been employed so far as possible in the present study of the 2,604 Illinois water wells built for municipal supply.

As part of the study, data on water well experience were classified and compiled, producing some unexpected findings in trends in service life of wells, and a statistical review of ground water practice was prepared to measure the factors that contributed to these trends and that may affect them in the future.

Growth of Ground Water Use

The increase in public ground water supplies and in population served for the period from 1868 to 1948 is shown in Fig. 1. Use of ground water received its first widespread development in the 1880's and has been increasing ever since that time. The great majority of Illinois municipalities and urban population is now served by public water supply systems. Growth in the number of these systems has been accompanied, in recent decades, by the transfer of many community supplies from ground water sources to surface water sources.

It has proved difficult to estimate trends in ground water use, as production records for ground water undertakings were not easily obtained. Production records were available from only five Illinois communities for the years 1900–1947. These cities, which, in 1950, had populations ranging from 12,000 to 93,000, were Aurora, Champaign-Urbana, DeKalb, Elgin, and Rockford. The curves in Fig. 2 were plotted from the data collected in these cities. As will be noted from the per

capita production curve, there has been a definite increase for each decade since 1900 and an especially large increase since 1940.

Histories of Installed Wells

A chronologic record of wells built, abandoned, retired, kept as standby, and maintained in active service was prepared in accordance with the following definitions: Wells that were permanently removed from service by the operators or not equipped for service

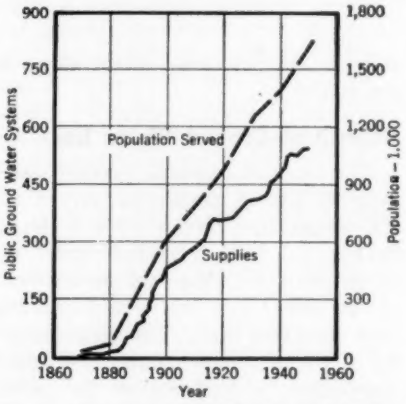

Fig. 1. Increase in Public Ground Water Supplies and Population Served

Data for period 1868–1948.

and no longer used as a part of a public ground water supply system were considered "retired." "Abandoned" and "standby" were included in the category of retired wells throughout this study except in Fig. 3, where they are necessarily shown separately. The "abandoned" wells were those which were removed from service in communities that discontinued the use of ground water. "Standby" wells were those still equipped with pumps but rarely used. Many standby wells were poorly equipped for pumping and no longer able to supply the public demand. Not all of them were maintained in condition for service and the majority were slated for retirement. Only 6 per cent of the wells in this category contributed to the public supply, and most of these furnished only 1–5 per cent of the total.

Figure 3 shows a decline in number of wells in active service after 1918. The population-served curve in Fig. 1 and the curve of the trend in per capita production in Fig. 2 both show increases. Nevertheless, there are fewer

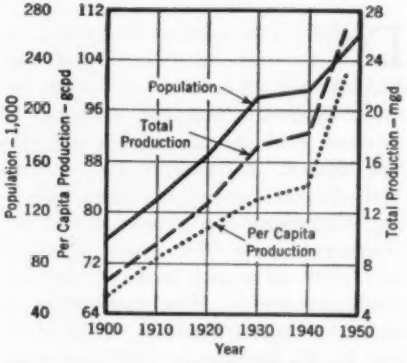

Fig. 2. Trend in Ground Water Production in Five Illinois Cities

Data for Aurora, Champaign-Urbana, DeKalb, Elgin, and Rockford for years 1900–47.

wells in active service today than there were 35 yr ago. This unexpected discovery indicated the need for a more detailed production analysis. Production data were supplied by the Div. of San. Eng., Illinois Dept. of Public Health from surveys of public water supplies in 1938, 1940, 1944, and 1948. These values, shown as small circles in Fig. 4, were used in computing the per capita production for the corresponding years.

Per capita production for the state as a whole was somewhat below that shown in Fig. 2 for five of the larger Illinois communities. The five-decade curve in Fig. 2 was therefore proportionately lowered to match the 1938 and 1940 per capita figures for the entire state. This modification produced an estimated statewide per capita production curve from 1900 to 1950 that permitted estimating total production from 1900 to 1938 as shown in the curve in Fig. 4.

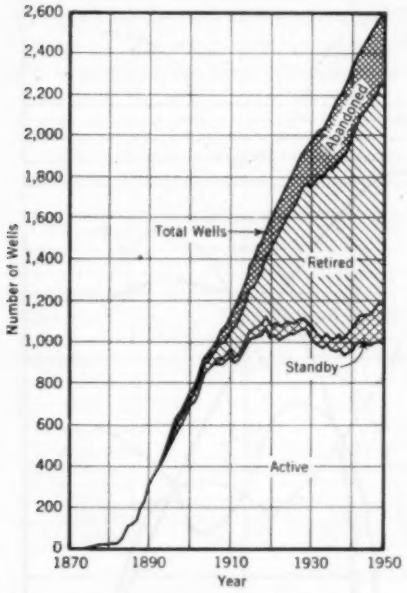

Fig. 3. Chronologic Record of Wells in Illinois Public Ground Water Supply Systems

A decline in wells in active service since 1918 is noteworthy.

From a combination of the production estimate and the data of Fig. 3 on the number of wells in active service, the curve in Fig. 5 which shows that individual-well production on a 24-hr basis increased from 38 gpm in 1900 to 94 gpm in 1948 was derived.

Water-Bearing Formations

The principal water-bearing formations* in Illinois are listed in summary form in Table 1. The figures used in this table are not the extreme limits of the characteristics of the formations, but they indicate the limits generally encountered. A few drift wells, for example, are more than 300 ft deep. The hydraulic characteristics of the unconsolidated materials and various limestones are extremely variable, whereas the sandstone materials display more uniform characteristics.

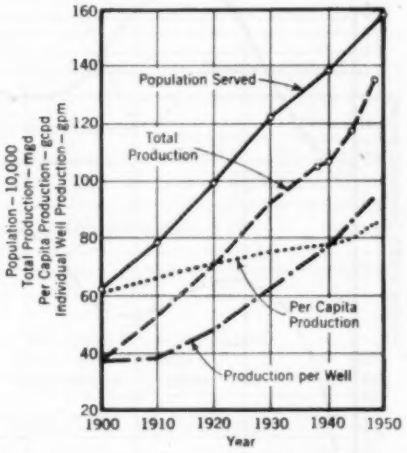

Fig. 4. Demands on Illinois Municipal Wells

Data from State Department of Public Health surveys in 1938, 1940, 1944, and 1948.

Almost all Illinois wells drilled in limestone or sandstone operate without

* In this study, the formation names that classified these wells are those given by the Illinois State Geological Survey as the bottom formation penetrated by each of the wells.

screens. Liners, or casing sections, are sometimes necessary through caving strata. Certain wells drilled into sandstones, particularly the Cambrian sandstones, have been improved by the use of explosives, or shooting. Although the upper limit of the coefficient of transmissibility for Ordovician sandstone is shown in Table 1 to be 50,000 gpd per ft, this value is attained only in certain limited areas. Ordovician material usually offers a productive capacity that is no better than that of the Pennsylvanian and Mississippian sandstones.

Types of Wells

The rates of installation of wells of various types in Illinois are shown in Fig. 5, which gives data on wells in unconsolidated materials, and in Fig. 6, which gives data on wells drilled into bedrock. Of significance is the fact that the open-bottomed wells, represented by Curve *A* in Fig. 5, which were widely used in the 1890's, are now rarely found. Dug wells, too, have lost their popularity. There has been a steady demand for the regular tubular wells, represented by Curve *B* in Fig. 5. Gravel-packed wells, porous-concrete-

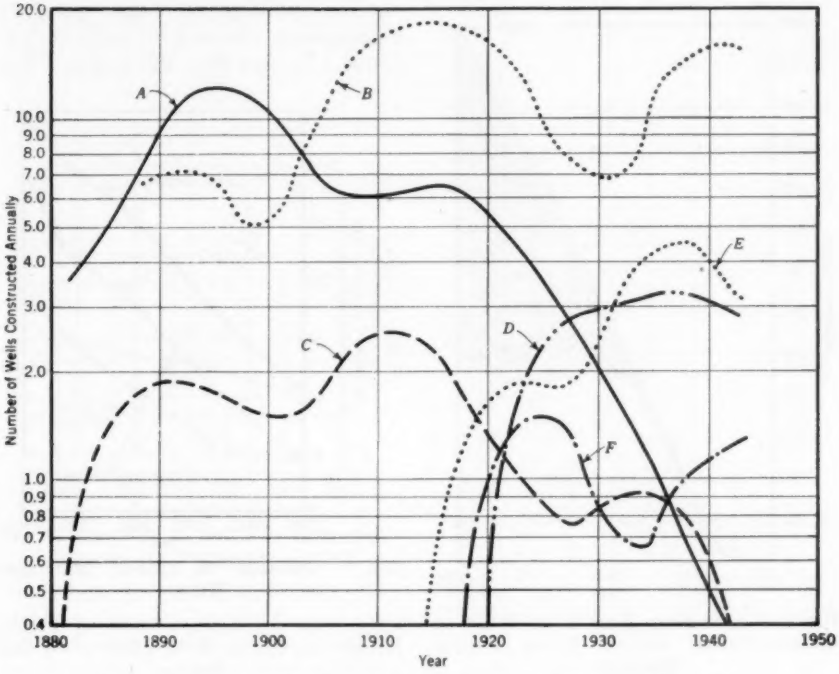

Fig. 5. Trends in Wells Constructed in Unconsolidated Materials

Figures are given in moving 10-yr averages. Curve A *represents unscreened wells with metallic casings; Curve* B, *screened wells without gravel pack; Curve* C, *dug wells; Curve* D, *wells with porous-concrete screens; Curve* E, *screened wells with gravel packs; and Curve* F, *wells with perforated-concrete pipe.*

screen wells, and perforated-concrete-pipe wells, not widely used until after 1915, are sometimes favored.

Of bedrock wells, those drilled in the limestones and into the Ordovician and Cambrian sandstones have been in sustained demand. Wells drilled in the Pennsylvanian formations, introduced in the early 1900's, have been less widely used. Those drilled into Mississippian sandstones constitute a small fraction of the total number installed each year and have been constructed in appreciable numbers only during the last two decades.

TABLE 1

Characteristics of Formations Developed for Public Ground Water Supply in Illinois

Formation	Well Production During Test *gpm*	Well Depth *ft*	Field Coefficient of Transmissibility	Field Coefficient of Storage	Thickness of Water-Bearing Stratum *ft*
Unconsolidated Materials	5–5,000	20–300	?–500,000	0.0001–0.10	5–200
Limestone	5–2,500	50–700	—	—	—
Sandstones					
Pennsylvanian	5–50	75–300	500–4,000	0.00002–0.0003	10–150
Mississippian	5–75	100–450	250–5,000	0.00005	10–100
Ordovician	25–1,000	150–1,500	500–50,000	0.00005	50–250
Cambrian					
Galesville	250–1,500	750–2,800	3,000–25,000	0.00003–0.0006	50–150
Mt. Simon	50–800	1,100–2,300	—	—	50–500

Mortality Experience

In determining the mortality rates of the various types of wells, 1-yr intervals were used. Wells were considered to have been placed in service in the middle of the calendar year. Retirements of these wells were then considered to have had a life of ½ yr. If the well was retired during the second year, it was considered to have had a 1½-yr service life, and so on. The definitions used were:

1. *The service life* of a well is the period between the date on which the well was placed in service as a part of the supply system and the date on which it was retired from service in that system.

2. *The median service life* is the number of years that is greater than the life, at retirement, of half the wells, and less than the life of the other half.

3. *A mortality-survival curve* is a graphic representation that shows the proportion of survivors in a group of wells, from year to year, throughout the period of record.

Mortality-survival experience is summarized in Fig. 7 for all wells used for municipal supply in Illinois and for the three major categories of formation—limestone, sandstone, and unconsolidated. Median service lives of these wells and of those drilled into various bedrock formations are given in Table 2.

Figure 8 shows the mortality-survival curves for wells drilled in unconsolidated formations. The most sig-

nificant curve in Fig. 8 is Curve *C*, for wells with unscreened metal casings or for those with open bottoms. Median service life for these wells was 21 yr; for other types it was greater. As noted later, the data shown for wells with porous-concrete screens are not wells appear approximately similar. As the use of dug wells has been generally discontinued and as they were used in the earlier years when lighter demands were placed on them, it may be estimated that dug wells will have shorter service lives than will tubular

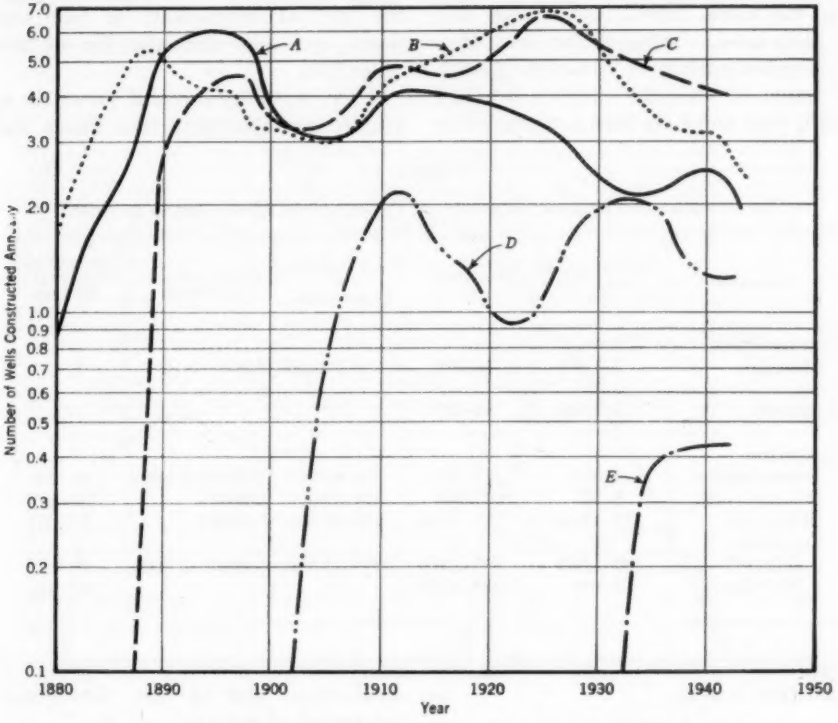

Fig. 6. Construction Rate for Wells Constructed in Illinois Bedrock Formations

Curve A *represents wells drilled in Ordovician formations; Curve* B, *in Cambrian; Curve* C, *in limestone; Curve* D, *in Pennsylvanian; and Curve* E, *in Mississippian.*

representative of general experience in Illinois.

Since less than one-third of the gravel-packed wells have been retired, the experience provided is too brief to establish their longevity definitely, but the mortality-survival curves for gravel-packed wells and for tubular-screened or gravel-packed, drilled wells.

The mortality-survival curves for wells drilled in the bedrock are shown in Fig. 9, a comparison of which with Fig. 8 indicates that the mortality experience with wells constructed in unconsolidated materials by almost any method is better than the experience

gained with the Mississippian or Pennsylvanian formations.

Causes of Retirement

As part of the survey, the records of the 2,604 wells under study were reviewed and classified according to the cause of retirement for each well. These data are partially summarized by well types in Table 3, which provides a great deal of information, especially when it is compared with Table 1. A review of the detailed observations on this subject, however, cannot be made available here.

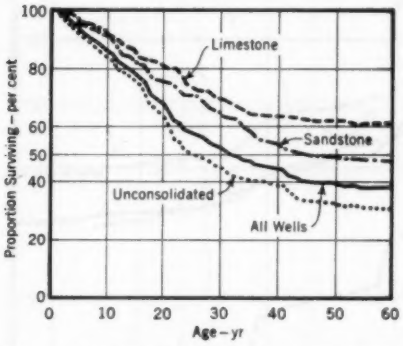

Fig. 7. Mortality-Survival Experience With Illinois Wells

Wells in Illinois public ground water supply systems were studied from records covering the period 1875–1948.

The overall summary of retirement causes shows the most important group to be that involved with the water-producing formation: interference, overproduction, and formation depletion. Second in importance is the group including mechanical stoppages, such as entrance of sand into the well or well loss due to formation movement. All other causes combined produced less retirement than either of these two. Thus, it is indicated that more than half the retirements were caused by troubles involved with the water-producing formation. One-quarter of the retirements were due to well losses, most of which were caused mechanically by sand movement. The remainder of the retirements were attributable to miscellaneous causes. But the basic cause appears to be use of the well rather than its construction.

Trend in Service Lives

There has been a growing feeling in the water supply industry that the new techniques now employed in the design and construction of water wells have increased their service lives. An attempt has been made to determine, from the mortality-survival data, the trend in median service lives of wells. For this analysis, retirement and survival information was sorted into a number of construction-time periods, for each of which a separate mortality-survival curve was prepared. From these curves, the medians in Fig. 10 were plotted.

TABLE 2
Median Service Lives of Wells

Formation	Median Service Life yr
Unconsolidated	25.0
Limestones	60+
Sandstones	46.5
Pennsylvanian	18.3
Mississippian	11.8
Ordovician	41.8
Cambrian	60+

In Part *A* of Fig. 10 is shown the trend in service lives of all the wells. It will be noted that there was a general decline in service lives from the earliest record until 1920. Although an apparent increase in service life after 1920 was indicated, it is questionable whether this increase actually took place or was the result of an in-

correct method of analysis. Some increase might result from improved design and construction, but this improvement may be offset by the increased demands shown in Fig. 4.

In Part *B* of Fig. 10 are shown the service lives of unconsolidated wells, which represent 65.5 per cent of all wells built in the state. The decline in median service life for those built shortly after 1900 is much more marked than is the decline for all wells studied. This difference is probably more apparent because of the relatively short lives of wells in unconsolidated materials compared with those of wells drilled in bedrock. Combination of the year of construction and the median service life shows that at some time between 1920 and 1930 some factor caused a considerable decline in the service lives of existing wells.

It was impossible to prepare similar studies for the wells constructed in

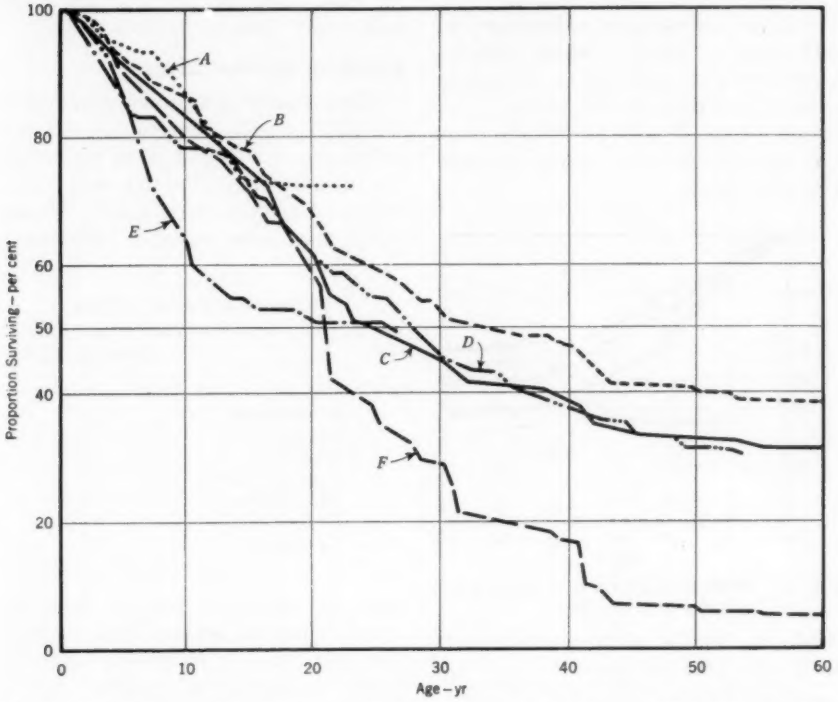

Fig. 8. Mortality-Survival Experience With Illinois Wells in Unconsolidated Formations

Wells in Illinois public ground water supply systems were studied from records covering the period 1875–1948. Curve A *represents screened wells with gravel packs; Curve* B, *metal-screened wells without gravel packs; Curve* C, *all unconsolidated wells; Curve* D, *open-bottom wells with dug masonry walls; Curve* E, *wells with porous-concrete screens; and Curve* F, *unscreened wells with metal casings.*

specific bedrock formations, because the number constructed was too small to provide representative values, and the actual service lives were of such great length that the series does not yield median values.

1900, when the service lives were approximately 30 yr, and (2) the construction period after 1910, when service lives were somewhat less than 20 yr.

Figure 4 shows that demands on wells have been increasing since 1910.

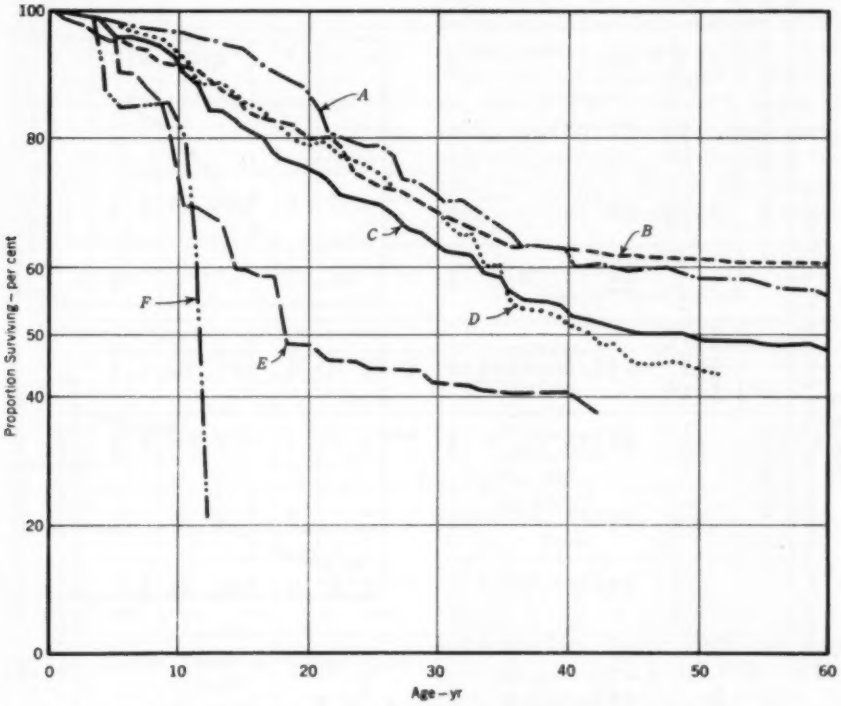

Fig. 9. Mortality-Survival Experience With Wells in Bedrock

Wells in Illinois public ground water supply systems were studied from records covering the period 1875–1948. Curve A *represents wells drilled into Cambrian formations; Curve* B, *all limestone wells; Curve* C, *all sandstone wells; Curve* D, *wells in Ordovician formations; Curve* E, *in Pennsylvanian; and Curve* F, *in Mississippian sandstone.*

The data in Fig. 10 disclose a period of marked decline in service life for the wells retired after 1923. Two distinctive service-life regimes are apparent: (1) the construction period from the earliest records to approximately

Available data do not permit a more precise estimation of the increase in pumping rates during the mid-1920's, at which time a sharp production increase may have hastened well retirements.

TABLE 3

Reasons for Abandonment and Retirement† of Wells*

Well Group and Subdivisions	Type of Construction	Total Wells				No. Wells Abandoned or Retired for Various Reasons‡						
		No. Constructed	No. Abandoned	No. Retired	Proportion Abandoned and Retired *per cent*	A Clogging	B Inadequacy	C Screen or Casing	D Quality	E Construction	F Miscellaneous	G Unknown
Unconsolidated												
Drilled	Unscreened casing, open bottom	353	45	280	92.1	121	137	15	41	8	1	2
	Metallic screen, no gravel pack	728	109	258	50.4	130	147	20	37	9	21	3
	Metallic screen, gravel pack	89	3	14	19.1	6	6	1	—	4	—	1
	Perforated ferrous casing	88	18	46	72.7	10	42	8	3	—	—	1
	Porous-concrete screen	83	4	31	42.2	28	—	6	—	1	—	—
	Perforated-concrete pipe	36	7	4	30.6	1	8	—	2	—	—	—
Dug	Masonry wall, open bottom	101	14	51	64.4	4	45	—	12	3	1	—
Driven points	Screened sand points	192	—	131	68.2	64	—	67	—	—	—	—
Infiltration galleries	Lateral tile and collection wells	12	3	1	33.3	—	4	—	—	—	—	—
Springs	Collection wells	17	—	17	100.0	—	1	—	16	—	—	—
Mine shafts	Timber	10	3	7	100.0	—	5	—	3	2	—	—
TOTAL		1,709	206	840	61.2	364	395	117	114	27	23	6
Limestone												
Mississippian	Ferrous casing to rock	23	—	9	39.1	—	6	1	1	1	—	—
	Springs piped from caves	5	—	1	—	—	1	—	—	—	—	—
Devonian	Ferrous casing to rock	14	1	2	21.4	1	1	—	1	—	—	—
Silurian	Ferrous metal casing to rock	199	8	54	30.7	1	49	4	—	1	7	—
	Springs piped from caves	3	—	—	—	—	—	—	—	—	—	—
Ordovician	Ferrous casing to rock	22	1	4	26.1	—	1	—	2	1	1	—
	Springs piped from caves	1	—	1	—	—	1	—	—	—	—	—
TOTAL		267	10	71	30.3	2	59	5	4	3	8	0
Sandstone												
Pennsylvanian	Ferrous casing and liner	83	28	21	59.0	1	48	—	—	—	—	—
Mississippian	Ferrous casing and liner	42	30	3	78.6	—	31	—	2	—	—	—
Ordovician	Ferrous casing and liner	234	14	84	35.8	1	66	5	21	5	—	—
Cambrian												
Galesville	Ferrous casing and liner	127	27	24	40.9	1	43	1	5	1	—	—
Mt. Simon	Ferrous casing and liner	142	30	23	35.9	—	38	1	12	2	—	—
TOTAL		628	129	155	45.2	3	226	7	40	8	—	—
TOTAL (ALL GROUPS)		2,604	345	1,066	54.2	369	680	129	158	38	31	6

* Abandoned wells constitute all wells in abandoned public ground water supply systems.
† Retired wells are wells retired from existing public ground water supply systems.
‡ Key to detail of reasons for abandonment or retirement:
A—Sand filling; clogged screens, blocked formation.
B—Inadequate supply; declining capacity; recession; depletion; influence of other wells.
C—Corrosion, disintegration, or defects of screens or casings.
D—Objectionable quality and contamination.
E—Cave-in; lost tools and pump parts; construction difficulties.
F—Site location; uneconomical operation; decreased demand.
G—Unknown causes.

Types of Pumps

Some idea of the demands placed on wells may be obtained by studying the method used for removing water from them. Data on the pumps and methods used for taking water from 2,402 wells, by type of pump and year of installation, are summarized in Table 4, and shown graphically in Fig. 11, using 8-yr moving averages.

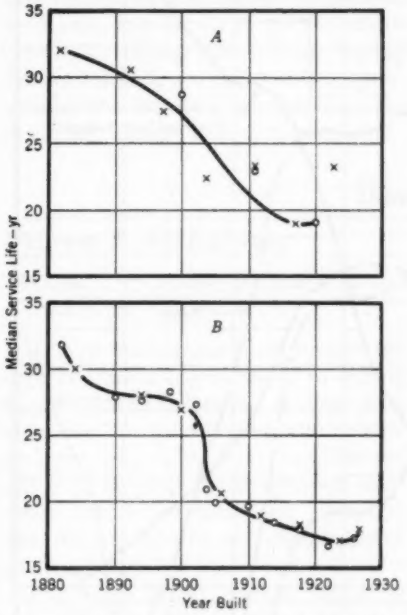

Fig. 10. Moving Trend in Service Life of Wells

Part A *shows the curve for service lives of all wells built in Illinois; and Part* B, *of unconsolidated wells built in the state. Circles indicate moving 8-yr medians; and "X's" moving 12-yr medians.*

The number of free-flow wells consistently declined. Suction-lift pumps, drawing either from single wells or from groups of wells, were commonly used in the 1890's and were of some prominence around 1920, but they appear to be less generally used today. Air-lift equipment, often found between 1895 and 1925, is now apparently rare. Plunger pumps, widely employed in the 1890's, declined in acceptance in the early 1900's but regained wide popularity upon the development of the double-acting plunger pump. This equipment continued to gain favor until the middle 1920's, when it began to decline rapidly. Probably the greatest single factor causing the decline in use of all these methods was the development of the high-capacity, vertical-turbine pump. A few of these pumps were installed before 1910, but they were not widely used until 1920. Since then, they have been a major factor in making possible the increase in production rates of wells.

TABLE 4

Water-Removal Methods

Method	No. of Wells
Turbines	1,065
Plungers	582
Air lifts	276
Suction lifts	332
Free flow	129
Jet pumps	18
TOTAL	2,402

In Illinois, the tendency toward greater production rates for each well has been offset by the increased understanding of ground water development during the past 15 yr. This understanding is leading to more conservative design and to attempts to forestall early well retirements by installation of wells pumping at moderate rates. The recent increased use of jet pumps, which are useful in smaller

communities and are generally of smaller capacity than vertical-shaft turbine pumps, illustrates this tendency. Conservative well exploitation by state agencies and engineers has led to the reintroduction of some plunger pumps for small wells. Also, submersible motor-driven pumps have attained considerable use in recent years. These developments, however, have been too recent to show their effect in Fig. 11.

Summary and Conclusions

In Illinois, the number of public ground water systems and the quantity of water provided from ground water sources have expanded rapidly, but, since 1915, the number of wells in active service has decreased. An analysis of production estimates indicates that wells are being exploited more intensively than they were in 1910.

More than half of all retirements

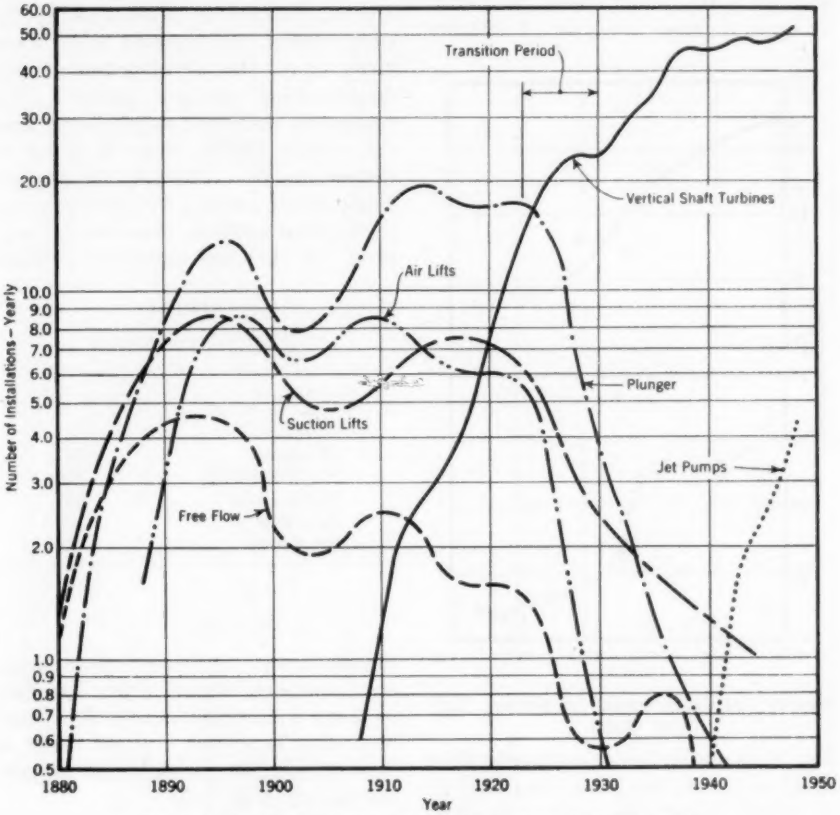

Fig. 11. Methods of Removing Water From Illinois Wells

Moving 8-yr averages used in computing graph. It should be noted that plunger type pumps during the 1890's were predominantly single-action and from 1910 to 1920 were predominantly double-action.

were found to be attributable to formation problems, such as interference, recession, overproduction. Less than half were due to failure of the wells. Although the data do not give a clear picture of trends since 1925, analysis of the data reveals a marked decline in the service lives of wells. Either development in construction procedures during the first decade of the Twentieth Century or changes in well use during the third decade are apparently responsible for the decline in service life. No significant change in construction practice is known to have been widespread, but the vertical-shaft turbine pump came into wide use during the 1920's, replacing previous lower-capacity equipment. The decline in service lives of wells is attributed to their increasingly intensive exploitation.

References

1. HARDING, JAMES C., ET AL. Useful Life of Water Wells. Jour. AWWA, **39**:32 (Jan. 1947).
2. *Survival and Retirement Experience With Water Works Facilities.* Am. Water Works Assn., New York (1947).

Discussion

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It is a far-sighted policy that the state of Illinois has followed in setting up its various agencies dealing with wells, well water supplies, and related geology. Far-sighted, too, has been the policy of keeping these agencies completely state-controlled and operated, with no dependency on federal money or departments.

The State Water Survey has done an outstanding job of maintaining statistics through the years, making available a precise record of the constantly changing status of well water supplies. Only because such data have been collected, tabulated, correlated, and published is a study such as that presented above possible.

Another agency, the State Geological Survey, maintains complete records of well logs, and has interpreted the information in terms of its bearing on the problems of fresh water supplies. Much factual data has been recorded, and the survey is continuously improving its understanding of underground strata and their bearing on water production.

The two surveys, with their competent personnel, have been the good friends of well contractors in Illinois. No responsible driller would fail to file logs, furnish samples, or provide test data, despite the fact that there is no effective law of the state which requires such action.

The study published here is a signal contribution to the subject of well mortality and is so well authenticated that no disagreement with the data presented is possible. Some comments concerning deep wells in consolidated bedrock formations, including a historical review of some of the changes in well practice since 1868, may be of value.

Water Levels

Eliminating from consideration wells in Mississippian and Devonian limestone, as well as in Pennsylvanian and Mississippian sandstone, the writer may note that he has found very little change in the static water levels of first-bedrock aquifers. This source has

always seemed able to sustain production with very little change. Artificial modification, such as overproduction and allowance of interflow near single top-aquifer wells, alters conditions. For units near single top-aquifer wells, declining capacity is hardly a reason for abandonment. Many such wells need only careful and intelligent engineering attention to give further useful service.

Because first- or top-bedrock wells usually could not provide adequate supplies for increasing needs, deeper drilling was necessary to tap additional aquifers. This step precipitated many well problems which led eventually to premature retirement. Before 1900, the deeper Ordivician and Cambrian sandstone wells were drilled to take advantage of their strong natural flows. Contractors were very careful to tube the finished well properly for flow. In other words, they installed a string of pipe with a packer on the bottom from the ground surface to the impervious strata below the top aquifer. If this practice were not followed, the top bedrock would steal the water, and natural flow would not result. Well owners, water works superintendents, and engineers were thus alerted to the defect and no time was lost in making repairs to restore flow.

The static levels of deep sandstone formations, have, on the other hand, dropped gradually. In northern Illinois, and particularly in the metropolitan Chicago area, the water levels had, by 1910, receded below the static water level of the top-bedrock source. For several decades before and after 1910, deep sandstone wells were constructed with a minimum of casings. Liners were generally installed only opposite formations that were likely to cave in. This practice, together with the continuous lowering of the sandstone water table, directed the interflow downward from the top formation —usually limestone—into the deep sandstone sources—an unfortunate condition which deteriorates progressively until it corrects itself naturally. In such wells, the upper water is usually quite highly mineralized, but, in flowing down the well bore—often in cascades—is aerated, thus becoming unstable. By this means the water loses some of its mineral compounds, which filter through the exposed sandstone surfaces of the bore. This action will, in time, seal the sandstone so effectively that it will neither take nor deliver water, thereby causing the retirement of another well or, even more serious, the search for another source of supply.

As soon as interflow ceased to give visible evidence of defect, many people dealing with the well water supply problems became complacent. Maintenance was neglected, and more wells of the same type were constructed. Not until 1930 were specifications changed to reflect an intelligent understanding of these fundamental problems. And only since then has consideration been given to the confinement of aquifers, effective well plugging, and the development of single-aquifer wells.

Reasons for Retirement

The authors were historically correct in explaining the reason for well retirement, but additional reasons, equally real and relevant, are:

1. Wells are retired because of the lack of overall planning and study of the water supply sources—that is, deep wells are drilled where glacial-drift wells should have been drilled, and limestone wells with complete treatment are constructed instead of wells in deep sandstone. The availability of softer, deep-well water may cause the

retirement of sources that produce harder water.

2. Wells are retired long before they have fulfilled their life expectancy because of improper maintenance or too little engineering thought to the factors involved. The geology of the given situation is regarded as just so many facts that are not applied to the hydraulics and the hydrology of maintenance problem. Makeshift repairs, or attempts at repairs, which offer little relief are made. Cement and sand have been poured around a well liner, and the owner or engineer has been satisfied that a proper cementing job was performed. The same owner or engineer, however, would, rightfully, not allow the footing for an elevated tank to be poured into a pit that was full of water. Attempts to repair wells have failed because the differences in pressure between formations were not taken into account. In the Joliet area, for instance, a differential pressure of almost 400 ft has been found between the Mt. Simon and Galesville sections of the Cambrian sandstones.

3. Good wells are retired because of political expediency. In some localities, inadequacy of the water supply systems is blamed on the failure of wells, the lowering of water tables, the caving in of formations, the need for development. Public opinion is thereby guided, for political purposes, toward discontinuing the use of wells.

Conclusions

Today, many kinds of specialists are devoting time and thought to well retirement problems, and their studies will definitely alter retirement practices. Undoubtedly, when the figures in the preceding paper are plotted beyond 1948, favorable changes may be expected in some of the curve gradients.

Instruments for obtaining information on the behavior of wells have been and are being developed and used to advantage. Various geophysical instruments have disclosed much information. Special flowmeters for interflow investigations, temperature-caliper studies, and numerous other specialists' tools have been most helpful.

Employment of better techniques by contractors, new drilling methods, new procedures in well development by "shooting", and new procedures for cementing of casings and liners have all been adopted as a result of knowledge gained from the experience of the oil industry. Chemical treatment of wells, acidizing, and application of polyphosphates for the removal of objectionable constituents are in early stages of development.

However much progress has been made to date, though, there is no question but that much improvement is still possible in planning, construction, and maintenance of wells to provide longer periods of trouble-free performance.

The Precision of Microscopic Counts of Plankton in Water

By Edward W. Moore

A contribution to the Journal by Edward W. Moore, Assoc. Prof. of San. Chemistry, Harvard Univ., Cambridge, Mass.

THE identification and enumeration of microscopic organisms in water form a useful and informative part of water analysis, which finds application in many aspects of water, sewage, and waste control. A substantial section of *Standard Methods* (1) is devoted to the technique of microscopic counts. Comparatively little attention, however, seems to have been given to the precision of the microscopic counts conducted according to the directions set forth. In *The Microscopy of Drinking Water* (2) it is stated "that the results of counts made by the Sedgwick-Rafter method are usually precise within 10 per cent; i.e., two examinations of the same sample seldom differ by more than this amount." No person experienced in making microscopic counts has ever felt too certain of the validity of this statement. The procedural sources of error, such as errors of sampling and sand error, are discussed in some detail in *Microscopy*. Of these, the error of random sampling from a large body of water is undoubtedly the greatest, and must itself often exceed the given figure of 10 per cent. Some slight mention is made of errors due to unequal distribution of organisms in the counting cell, but it is said that these counting errors cannot be readily stated in figures. With modern statistical methods, however, the counting errors can be determined directly from tabulated results. This article describes an attempt to obtain, from a statistical examination of a large number of data from several sources, some evidence of the magnitude of counting errors, and from this information to make estimates of the reliability of the counting procedure.

Standard Method of Count

The standard method for making microscopic counts involves: concentration of the sample by means of filtration or centrifuging; placing a 1-ml sample of the concentrate in a Sedgwick-Rafter cell; placing this cell under a calibrated microscope with a suitable ocular micrometer; and enumerating, in terms of numbers of individuals, areal standard units, or cubic standard units, the organisms in ten random fields of the microscope (five fields if the centrifuge is used). The observed counts of the fields are summed, and the appropriate factors are applied to convert the result into count per unit of the original sample. What is actually being determined, however, is the mean, or average, count of the fields, and the question to be answered

is: "How well does this average represent the true average of the concentrate in the Sedgwick-Rafter cell?" This is a statistical problem, involving the theory of random sampling, and, as will be shown presently, it is likely that the errors inherent in this last step of the procedure are usually larger than those of the other steps. One does not, however, need to be an expert statistician to feel sure that a count in which the fields contain 80, 120, 100, 70, 90, 130, 110, 120, and 130 standard units will give a much more dependable result than a count in which the fields run 3, 150, 0, 157, 52, 3, 255, 53, and 202 standard units. These are two examples taken from a collection of actual counts. The means of the two series are not greatly different—105 and 88 standard units, respectively—and since the concentration was the same in both units tested, the computed values for the original samples were 2,100 and 1,760 standard units of organisms per milliliter. If only the probable error of the counting procedure is considered, however, the precision of the first result is ± 2.5 per cent and that of the second, ± 33 per cent.

Another question which can be answered by statistical methods is whether the precision obtainable by counting a given number of fields—for example, ten—is sufficient for the use to which the data are to be put. It is obviously a waste of time to count more fields than necessary, but it is also wasteful to make counts which are not sufficiently precise to be meaningful for interpretation of results. A statistical examination of a large number of actual microscopic counts should provide answers to some of the questions suggested in the foregoing paragraphs.

Statistical Measures of Precision

Given a series of numerical values—in this study, a series of counts of organisms in the individual fields—containing n numbers, and representing these numbers as $X_1, X_2, X_3 \cdots X_n$, the mean, M, or average of these numbers is determined simply by adding the numbers and dividing by n:

$$M = \frac{X_1 + X_2 + X_3 \cdots X_n}{n}$$

The reliability of this mean as a representation of the number of organisms in the entire concentrate in the Sedgwick-Rafter cell is determined by two factors: [1] the total number of values, X, or fields counted, and [2] the variability observed in the values, X. Obviously, if enough fields are counted to cover the entire cell, the reliability is 100 per cent, whereas if very few fields are counted, the reliability is much less. Also, if the observed numbers in the fields vary widely, more fields will have to be counted in order to secure a reliable average than will be necessary if the distribution of organisms in the concentrate is uniform. Mathematically, these considerations can be summarized briefly as follows:

The standard deviation of the series $X_1, X_2 \cdots X_n$, designated as s, can be defined as $s = \sqrt{\frac{\Sigma(X - M)^2}{n - 1}}$. Here the quantity $\Sigma(X - M)^2$ represents the sum of values, $(X_1 - M)^2 + (X_2 - M)^2 + \cdots (X_n - M)^2$.

The computation of s can be simplified by using the alternative formula, $s = \sqrt{\frac{\Sigma X^2 - nM^2}{n - 1}}$. Here ΣX^2 means $X_1^2 + X_2^2 + \cdots X_n^2$.

The coefficient of variation of the series is the standard deviation of the series, expressed as a fraction of the mean: $C_v = \frac{s}{M}$. It can be shown that

$$C_v = \sqrt{\frac{\frac{\Sigma X^2}{M^2} - n}{n - 1}}.$$

The standard deviation of the mean value, M, expressed as a percentage of the mean, is given by the equation

$$\% \text{ S.D. of Mean} = P = \frac{100 C_v}{\sqrt{n}}.$$

This value gives us a measure of the precision of the mean. Its significance can be stated as follows: There is approximately a two-thirds chance* that the observed mean count, M, of the n fields is within $\pm P$ per cent of the true mean count for the entire cell. There is also approximately a 95-per cent likelihood that the observed mean is within $\pm 2P$ of the true one for the cell contents.

An example of the computation is provided by a count of Wenham Lake in Beverly, Mass. The predominant organisms were *Tabellaria* and *Asterionella*. The individual fields showed 20.6, 12.4, 20.6, 23.8, 18.6, 25.4, 26.6, 15.6, 14.2, and 6.2 standard units respectively. This gives a mean of 18.4 standard units per field. The sum of the X^2 values is 3,751. Hence:

$$C_v = \sqrt{\frac{\frac{3751}{339} - 10}{9}} = 0.35.$$

The percentage error of the mean is

$$\pm P = \frac{100 \times 0.35}{\sqrt{10}} = \pm 11 \text{ per cent.}$$

Thus, there is a high degree of probability (about $\frac{2}{3}$) that the true value of the total count of organisms for this concentrate is within 11 per cent of that computed from the results, or a practical certainty (95 per cent)

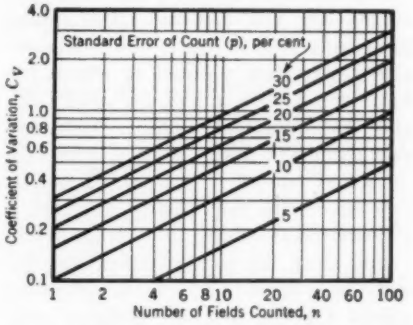

Fig. 1. Relationship of Coefficient of Variation, Number of Fields Counted, and Precision Secured

It will be noted that C_v must be 0.317 or less if precision as good as ± 10 per cent is to be secured from a count of ten fields.

* The expression, "approximately a two-thirds chance," is used in the interest of exactness. If the distribution of the observed field counts was a normal distribution, the chance would be 68.26 in 100 that the true mean was within $\pm P$ per cent of the observed mean. The distribution, however, becomes normal only if n, the number of fields counted, is quite large (30 or more). For smaller values of n, the probable range of the true mean, or the confidence limits of the calculated mean, can be computed by the use of Student's t-distribution, which is discussed in most standard works on statistics (for example, *Statistical Methods for Research Workers*, by R. A. Fisher). The differences, however, are comparatively small if the number of fields counted is reasonable. When ten fields are counted, for example, the standard error (68.26 per cent range) of the mean given by Student's t-distribution is only $\pm 1.06\ P$, where P is the standard error for the normal distribution. If only three fields are counted, however, the standard error by Student's t-distribution becomes $\pm 1.33\ P$, a very material increase.

that the result is dependable within 22 per cent. These statements refer, of course, only to the counting error and do not take account of any errors in sampling or in the concentration of the sample. The sampling and concentration errors are often said to be of the order of 5 or 10 per cent, although very few data have ever been published to confirm these values. If correct, it would appear that the counting error is generally greater than the errors attributed to sampling and concentration.

A general knowledge of the range of coefficients of variation secured in microscopic counts will not only permit estimation of the precision of results but, conversely, will permit estimation of the number of fields which must be counted to secure a desired precision. In this way, considerable saving of time may be effected if extreme precision is not desired, or, on the other hand, any desired precision may be secured, within the limitations of the technique. For example, if an observer from previous experience knows that the C_v of counts from a given source is rarely over 0.5 and he desires to secure a precision of ± 10 per cent on the sample at hand, he must count $n = \frac{(100 \times 0.5)^2}{(10)^2}$, or 25 fields, to secure this precision. If he can be content with a precision of ± 25 per cent, only $n = \frac{(100 \times 0.5)^2}{(25)^2}$, or 4 fields, will be necessary. Figure 1 shows the relationship between C_v, number of fields counted, and precision secured. It will be noted that C_v must be quite low (0.317 or less) if a precision as good as ± 10 per cent is to be secured from a count of ten fields.

Observed Magnitudes of Coefficients of Variation

In an attempt to determine the range of the coefficients of variation observed in actual microscopic counts, the author has collected a series of 222 actual counts drawn from a wide variety of sources and made by a number of different individuals. A small proportion of these were made by students in the author's laboratory on samples collected from local ponds and streams and from an artificial stream maintained in the laboratory. The bulk of them were secured from three sources: Kenneth F. Knowlton and Francis J. Brown, respectively Chemist and Lab. Asst. of the Water Supply Board of Salem & Beverly, Mass., who provided counts from past records and calculated the variances; Samuel O. Swartz, Biologist, Metropolitan District Commission, who contributed counts from the records of the Boston water supply reservoirs; and Lazarus Rubin, Chief of the Water and Sewage Labs., Massachusetts Dept. of Public Health, who patiently sorted out and computed results for a large number of counts—differing widely in source, character, and density of organisms—from the very extensive file of the department's records. It is believed that a sufficiently wide assortment of data has been collected to avoid any local or individual bias, but one must bear in mind the tendency in selecting data of this type to choose a rather high proportion of the more striking or unusual results.

For each count, the mean of all fields (usually ten) and the coefficient of variation, C_v, were computed. Figure 2 shows the distribution of the values of C_v obtained, in the form of a probability plot. The fact that a straight-line relationship is obtained has no

particular significance, but does facilitate analysis of the results. In practical terms, the information derived from the plot is as follows: One can expect to have a C_v less than 1.0 in 89.2 per cent of all counts; a C_v less than 0.7 in 74.4 per cent; less than 0.45 in 56.4 per cent; and less than 0.317 in about one-third (33 per cent) of all counts. It is interesting to note that the students, being relatively less experienced (one might even use the word "sophisticated") in counting, tended to show somewhat higher C_v values than the other workers. If the student results are left out, approximately 90.5 per cent of the remaining C_v values are below 1.0; 79.5 per cent, below 0.7; 61.2 per cent, below 0.45; and approximately 40 per cent below 0.317.

Since there is evidence of variation among individuals, it cannot be expected that any given investigator will encounter the same distribution of C_v values as is shown in Fig. 2, which represents an average of a number of independent workers. To arrive at precise conclusions regarding his own range of errors, an investigator should determine the distribution of C_v values in his own results, using the method described in the first part of the article.

In terms of the precision expected from microscopic counts, as far as the counting procedure only is concerned, if ten fields are counted, $C_v = 1.0$ means a precision of $\pm$ 31.7 per cent; 0.7 means $\pm$ 22 per cent; 0.45 means $\pm$ 14 per cent; and 0.317 means $\pm$ 10 per cent. It is evident that counting ten fields does not usually lead to very high precision. It is also evident that if the mechanical errors, such as those of filtering, concentrating, and pipetting, are as low as stated in *The Microscopy of Drinking Water*—in the vicinity of 5 to 10 per cent—the counting procedure is far less precise than the laboratory technique. Or, putting it another way, if a precision of $\pm$ 10 per cent were required, in a sample where $C_v = 1.0$, one would have to count 100 fields, whereas for $C_v = 0.7$, only about 49 fields would be necessary. Evidently an improvement in the values of C_v observed would be highly desirable. The next step, therefore, was to analyze the data in order to determine whether any particular factors tended to produce high C_v values.

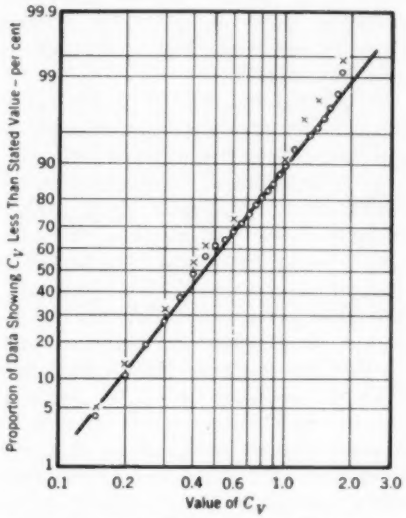

Fig. 2. Distribution of Coefficient of Variation for 222 Microscopic Counts

Circles indicate plot of results reported by all workers; crosses indicate these results less the results reported by students.

The data were first grouped according to the size of the mean count per field, with the results given in Table 1. The differences are not very consistent or significant, except that it may be said that there is a tendency toward higher values of C_v in Group I, where the counts per field are low. Best re-

sults seem to be secured in the 20–50 standard units per field group, Group II. This, then, might be a range to be favored in considering the degree of concentration of samples. The statement in *Standard Methods* that the higher degree of concentration secured by the centrifuge permits reducing the number of fields counted to five appears somewhat questionable in view of these results. At any rate, it is not the number of organisms per field that is important, but the distribution of the organisms in the cell.

According to theory based on the assumption that the individual field counts are distributed according to a Poisson series, the variation of C_v with the mean count per field, m, can be expressed by the equation $C_v = \frac{1}{\sqrt{m}}$. For small values of m, C_v would be large, and this conclusion is supported by the results. At the higher values of m, however, one does not get the expected decrease in C_v, possibly because the more concentrated samples contain a larger number of specimens in which clumping or the presence of a few large organisms gives irregular distribution in the counting chamber. Theoretically, the relative error of the mean should depend only on the total number of organisms counted, and should be independent of the number of fields, but none of the data presented in this article can be employed to test this conclusion, since all counts were of ten fields.

Reasons for Low Precision

A detailed examination of the individual counts in comparison with their C_v values leads to certain conclusions about the reasons for high C_v values (or low precision). A good count shows a quite uniform distribution throughout the fields; the Wenham Lake count used earlier for the computation example is an illustration. An example of an unusual count is Sample No. 147,447 of the Massachusetts Dept. of Public Health. Taken from a pond in Shrewsbury, it contained a variety of organisms, including *Oscillatoria, Monas, Tabellaria,* and *Anabaena.* The count, by fields, was 200, 195, 237, 208, 198, 203, 212, 206, 187, 179; from this a value of $C_v = 0.078$ is obtained. This low value is almost too good, and can only be said to be either very unusual, or to indicate some error in technique. Exceedingly low values of C_v should be regarded with some suspicion.

Those counts giving relatively high values of C_v showed, in general, one or more of the following characteristics:

1. *Extremely low counts in the fields.* An example is one of the Salem-Beverly water supply counts, in which *Staurastrum* was the only organism present. The fields ran 0.1, 0.0, 0.3, 0.2, 0.6, 0.0, 0.1, 0.2, 0.0 in standard units. The value of C_v was 1.03. Several other examples of very low counts being the sole reason for low precision were also noted. When counts are as low as the above, variability tends to be magnified, and precision is low. Either counting a larger number of fields or preparing a new concentrate with greater density of organisms would seem to be the only possible remedies.

2. *Isolated large organisms which produce a small number of fields differing greatly from the rest.* An example is Massachusetts Dept. of Public Health Sample No. 148,336 from South Watuppa Pond, Fall River, Mass. The sample contained a wide variety of

diatoms and small green algae, but one field had a single huge *Volvox*. The counts by fields were thus 51, 72, 74, 959, 50, 54, 57, 74, 80, 62. The value of C_v is 1.85. If the single field containing the *Volvox* is dropped, however, C_v becomes 0.173. This is a common source of excessive C_v values. Large rotifers are the most frequent cause of the few excessively high fields. One is almost tempted to say that rotifers should not be included in the total count. Colonial organisms such as *Clathrocystis, Microcystics,* and *Coelosphaerium* might be expected to produce similar variability. This was observed in the present collection of data in two samples: state health department Sample No. 148,690, containing predominantly *Microcystis,* in which the distribution of counts was 3, 150, 0, 157, 52, 3, 255, 53, 5, 202, giving a C_v of 1.08; and Sample No. 148,540 containing *Coelosphaerium,* in which the distribution of counts was 8, 1, 7, 1, 12, 22, 2, 11, 1, 1, giving a C_v of 1.05. In the latter example the count per field is also low. Generally speaking, this difficulty can be avoided by dropping single large organisms from field counts if such organisms occur in only one or two fields. In such an example as the second, in which several fields are high, the only way to increase precision is to increase the number of fields counted. If the results are reported in terms of total numbers of organisms, the effect of large organisms is minimized, as is subsequently shown.

3. *A predominance of filamentous types of organisms.* There seems to be a tendency toward clumping and uneven distribution when the population consists largely of filamentous forms. An example is state health department Sample No. 148,239 from Great Pond in Weymouth, Mass. *Oscillatoria* and *Mougeotia* were the predominant organisms, and the field counts were 15, 5, 227, 254, 10, 73, 30, 25, and 50 standard units, an exceedingly irregular distribution, giving a C_v of 1.36. Numerous other instances are included in the collected data. The only way to increase precision seems to be to increase the number of fields counted. This is not to imply that filamentous organisms always give high C_v values; many samples containing predominantly filamentous organisms gave very even distributions and low C_v values.

Of the 24 samples giving values of C_v over 1.0, 5 appeared to have excessively low counts (under 10 standard units) per field, 9 contained single large organisms in a few fields, 9 were predominantly filamentous, and 1 showed no distinguishing charac-

TABLE 1

Comparison of Data Grouped According to Size of Mean Count per Field

Group	I	II	III	IV	Total
Range of Mean Count per Field, *standard units*	0–20	20–50	50–100	Over 100	
Number of Results Falling in Group	88	55	52	27	
Average Mean Count of Group, *standard units*	8.9	35	67.6	160	47.5
Average C_v	0.61	0.43	0.44	0.40	0.50
Median C_v	0.57	0.36	0.41	0.37	0.42
Proportion of C_v Values Over 1.0, *per cent*	11.4	5.5	19.2	3.7	10.8
Proportion of C_v Values Over 0.7, *per cent*	34.0	16.4	27.0	14.8	25.6

teristics. Of the 57 samples showing C_v values over 0.7, 17 had very low counts (under 10 standard units) per field, 18 showed badly distributed large organisms, 17 were predominantly filamentous, and 5 showed no distinctive characteristics.

Significance of the Results

It is evident that the statement, "microscopic counts are usually precise within 10 per cent," cannot be taken seriously if the standard ten-field count is used. Considering only the counting error and leaving out of consideration all other sources of error, the statement implies a coefficient of variation, C_v, of $\frac{10\sqrt{10}}{100} = 0.317$ or less. According to observation, this is true of only one-third of all counts, if the counts discussed in this paper are assumed to be representative. The hoped-for objective which inspired this investigation—namely, a possible reduction in the number of fields to be counted—has not been realized if a precision of the order of 10 per cent is demanded. Considering a C_v of 0.7 as the best normally attainable value, a ten-field count yields a precision of about 23 per cent. Reducing the number of fields to five gives a precision of about 30 per cent. It is possible that this degree of precision is really sufficient for many of the purposes for which microscopic counts are made.

The investigation has shown that certain factors tend to decrease the precision of the count. One of them is insufficient concentration of the sample, so that the number of organisms in each field is low. A figure between 20 and 50 standard units per field seems to be in the most favorable range, and below 10 per field the precision falls off rapidly. The occurrence of single large organisms in a few fields will seriously diminish precision, if the count is by areal or volumetric units. If the count is in terms of numbers of organisms without reference to size, the few large organisms do not affect the precision of the count; the same result is achieved by including the large organisms only in a survey count. A preponderance of filamentous organisms should suggest an increase in the number of fields counted if an expected precision is to be maintained.

It is not suggested that this study furnishes a definitive answer to the problem of the precision of microscopic counts. Information on the magnitude of coefficients of variation for a larger number of individuals and for a much wider geographical range is highly desirable. Furthermore, all data in the study are for counts on concentrates made by the Sedgwick-Rafter method. *Standard Methods* permits the number of fields counted to be reduced to five if the centrifuge method (Foerst high-speed centrifuge) of concentration is employed. It would be interesting to know whether the distribution of organisms in the centrifuge concentrate is really sufficiently more uniform than that in the Sedgwick-Rafter concentrate to justify such a reduction in fields counted.

The reporting of results in terms of numbers of organisms rather than areal or volumetric standard units should have only a slight effect on the standard errors of the microscopic counts. What little effect is exerted will be in the direction of lower coefficients of variation, since one of the causes of high values, namely, the occurrence of isolated large organisms, is eliminated when such organisms count as only one individual. For example, if Massachusetts Dept. of Public

Health Sample No. 147,447, previously cited, is expressed in terms of number of organisms per field, rather than as standard units, the count per field becomes 470, 349, 462, 420, 468, 446, 437, 476, 451, 449, and C_v is 0.084, which is substantially identical with the standard unit count C_v of 0.078. On the other hand, if Sample No. 148,336, cited as an example of the effect of a single large organism, is tabulated in terms of number of organisms, the count per field becomes 54, 67, 68, 42, 53, 46, 49, 77, 71, 55, and C_v is 0.20, which is very substantially less than the 1.85 obtained by the standard unit count. It may be safely concluded that the distribution of C_v values for counts made on the basis of numbers of organisms would be about the same as or slightly more favorable than the distribution reported here.

Summary

1. A statistical measure of precision —the coefficient of variation—has been applied to a large number of microscopic counts. This factor measures only the precision of the counting procedure itself.

2. The distribution of the values of the coefficient of variation follows a normal curve.

3. Approximately 75 per cent of the counts show a coefficient of variation of 0.7 or less, corresponding to a standard error for the counting procedure alone of ± 22 per cent for a ten-field count. Only one-third of the counts are precise to ± 10 per cent when ten fields are counted.

4. It is thus indicated that the error inherent in the counting procedure itself, when limited to ten fields, is considerably greater than that ascribed to the sampling and preparation for the count by authorities familiar with the procedures.

5. Indicated causes of unsatisfactory precision in the counts are: too few organisms per field; occasional large organisms in isolated fields; and preponderance of clumped, badly distributed filamentous organisms.

6. A method is presented whereby the precision of counts may be estimated, or the number of fields which must be counted to secure a given precision may be determined. This method may be applied by any laboratory making routine microscopic counts.

Acknowledgment

The author wishes to acknowledge the kind assistance of John C. Neess of the Univ. of Wisconsin, who read the original manuscript of this paper and made several valuable suggestions for its improvement. He also wishes to express his deep appreciation for the time and effort put into the project by Messrs. Knowlton, Brown, Swartz, and Rubin, as previously cited.

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Cuban Water Rates

Cuban Section Committee Report

A Cuban Section Committee Report presented on Nov. 13, 1951, at the Joint Meeting of the Cuban and Florida Sections, Fort Lauderdale, Fla. Members of the Committee were: Jose Garcia-Montes Jr., Civ. Engr., Havana; Luis Radelat, Engr. in Charge, San. Works, Public Health Dept., Havana; and Marino Diaz Quinones, Civ. Engr., Public Service, Marianao.

THIS report was instigated by a number of privately owned Cuban water utilities that are seeking a more equitable adjustment of water rates to make possible their financing of extensions and improvements to their systems. If current rates must prevail, many of Cuba's privately owned water works will not only be unable to undertake such projects, but may actually be unable to continue to exist. Although this may appear to be an excessively gloomy view, it remains a fact that three privately owned and operated works were recently taken over by the authorities and are now being operated as municipal utilities. According to published information, this action was taken because the private concerns failed to provide the service that was required by their franchises. The confiscations are now being contested in the courts.

Classification

Water works in Cuba are classified, according to ownership, in three categories: state, municipal, and private. Substantial differences in service rendered exist among the groups, these differences affecting the rates that are charged by each.

State Water Works

State water works comprise the largest and oldest plants, except for those of Havana and Marianao. Only a very few small water works were operating on the island before 1902, when, after the war for independence and the Spanish-American war, a Cuban government was established. The first constitutional law of this new government required that municipalities wanting to issue bonds for water works construction must obtain the approval of the majority of voters in a referendum in which at least two-thirds of the eligible electorate voted. As this provision was impossible to meet, few water works have been built by municipalities since colonial days. To comply with this section of the first constitution and yet provide service to the large cities, the central government, through its Department of Public Works, itself undertook construction of water and sewerage installations. Public funds were, of course, used to finance that work. This unfortunate precedent has largely been the reason for most of the present difficulties with which Cuban water works are faced.

Money to finance government water works construction was obtainable only by congressional action. Congressmen usually tried to obtain maximum funds for work in their own provinces and attempted to economize on projects in other provinces.

Engineers' estimates were naturally the bases of discussions, but final appropriations were almost always much less than these estimates. To obtain passage of a bill in both houses, many important items had to be scratched from the plans—filter plants had to be omitted, and even pipe capacity had to be reduced. Public Works Department engineers have often been unjustly blamed for the inadequate plants that were the result of these political dealings.

Because full discussion of a single project often endangered passage of a bill, many projects were divided into several parts, but this procedure effected no improvement as it was rare for all the parts to survive. Filtration of surface supplies was not provided for many years for such large cities as Santiago de Cuba, Camagüey, Cienfuegos, and Santa Clara, and some of them still have unfiltered water. As time passed, congressional approval was needed to finance necessary extensions. Cuba has a sanitary engineering department, but, because it is a governmental department, it is virtually powerless to force filter installation or otherwise enforce sanitary requirements.

Rates charged by the government water works were set arbitrarily by simple action of the Public Works Department, which operates the systems. As no capital charges were to be paid, the average rate was that computed by merely dividing the total operating expenses by the number of connections. The average rate was then apportioned haphazardly among the users in proportion to the rental value of their premises. This schedule is well liked by property owners, as it protects them against the high costs for excessive use by tenants which they would have to pay if meters were employed.

State rates are, of course, very low. There is every reason why they should be, when:

1. Construction costs are met by the government, and no capital charges are taken into account.
2. The water works as actually constructed do not comply with the most elementary requirements—not even providing filtration for surface water.
3. Rarely was the capacity of the system as originally designed adequate for more than a few years.
4. Much maintenance and extension work must always be deferred. No capital reserve is provided from operating revenues to make possible bringing plants to full capacity, as these funds also eventually come from public funds.

Municipal Water Works

As previously noted, municipally owned water works are few, primarily because constitutional requirements for their construction could not be met. The rate schedules of the few that exist require the approval of the Director of Sanitation.

Havana has the only important municipally owned and operated water works. Its ability to meet sanitary requirements and future needs depends in good part on its ability to copy the vicious practices of state systems. Only when the water shortage became acute in recent years did the municipality act to remedy the situation. For many years political interference pre-

vented the approval of a plan to extend and reconstruct the existing plant. The plan was finally approved in 1949 and work started. Since construction is being financed with surplus revenues, however, sufficient expenditure to complete the work quickly is not possible. Legal restrictions still prevent a major financial expenditure, but a law currently before congress will solve the difficulty.

Havana has a water supply that is fed half by gravity and half by pumping. The original works known as Albear Aqueduct were financed by municipal bonds which have already been amortized. The water rates, as originally prescribed, are among the few that allow extensions and improvements to be financed from current revenues, in spite of the fact that the rates were intended to apply to a gravity supply and now must cover a system in which 50 per cent of the total supply requires pumping.

Private Water Works

Privately owned and operated water works comprise the largest number of those in small cities and towns as well as those in some of the medium to large cities, including Matanzas, Ciego de Avila, and Cardenas. These water works operate under grants from the municipalities, which, since colonial times, have been issued for 30-yr periods. Only two towns, Baracoa and Sancti-Spiritus, have utilities which operate under the old indefinite grant. Under the 1902 Constitution, the municipal grants were subject to the approval of the governor of the province and the central government. Water rates required approval by the National Sanitary Commission. Under the 1940 Constitution, municipalities will have full power to grant concessions, but not until the complementary municipal law is approved by congress will this power be in effect. The National Public Service Commission, a recent quasi-autonomous organ of the central government, is empowered, meanwhile, to grant concessions; and the Sanitary Commission is also supposed to pass on the sanitary aspects of the projected water works.

The water utility concession requires that, among other items, the grantees must provide free fire service to the municipality and install the necessary hydrants. Other public services to be provided include sprinkling of the streets and a supply, without charge, to public buildings. In the interim between constitutional controls, the National Public Service Commission does not require the water works operators to provide these free services.

Water rates were originally approved by the municipality, but now they are also approved by the National Public Service Commission. Water rates must be passed by the National Sanitary Commission before the water works is given the status of a compulsory service. This status protects the water works from competition with such sources of supply as private wells or rainwater cisterns. When the status is declared, all premises must be connected to the public water supply and the approved rates are compulsory. Privately owned water works operating under municipal grants cannot force people to take their service unless they obtain from the National Sanitary Commission a "Declaration of Compulsory Service," which is granted if the rates are reasonable and other sanitary requisites are fulfilled.

Framers of the early water rate schedules were apparently obsessed

with a desire for simplicity. Thus, the schedule of the city of Havana, which was in force since 1858, with few exceptions, requires a payment of $20 annually from premises renting for up to $34 per month, and $40 per year from those with higher rentals. Many of the smaller water works charge uniform amounts to all premises. Records indicate that the old water rate of Matanzas, for example, was based on the number of outside windows, which were regarded as an index of frontage.

State and municipal water works have the right to impose a lien on the property, whereas privately owned water works are presently authorized only to discontinue service to delinquent accounts. When the water is turned off the sanitary department is notified, and the department places a "Prohibition of Tenancy," so that the house must be vacated. The tenant, of course, pays the standing debt if the owner does not and reimburses himself by withholding from the rent the amount paid to the water works. Until a few years ago, the sanitary department did not allow water works summarily to discontinue the services to delinquent accounts, and private water works operators had to resort to court action. This condition placed the private operators at a serious disadvantage when compared with the position of state and municipally owned utilities which had the right of eminent domain—a quick and effective means of collection. The arrangement by which prohibition of tenancy is imposed by the sanitary department, however, was hardly a satisfactory solution because, although action is directed toward the property owner, the tenant must become involved in a struggle in which he should have no part. In practice such matters must be handled with considerable care, and privately owned water works rarely collect as great a proportion of their bills as do the state or municipal utilities.

Improvements in Rate Schedules

In time, the basic requirement of simplicity was compromised to the extent of establishing schedules with three or more steps. These were framed, generally to conform to those charged by the state, on the basis that the National Sanitary Commission would not approve rates that materially exceeded those being charged by the state. The late Juan A. Cosculluela, for many years the engineer member of the National Sanitary Commission, who had considerable experience with the problems of private water works management, decided to approach the subject of flat water rates rationally. His first step was to define formally the word "moderate rate" as meaning one which permitted a utility to make both ends meet. He succeeded in obtaining the approval of the commission for a method of framing flat water rates proposed by one of the authors. The outcome of these efforts was a provision that each rate application required the official approval of the commission as a "moderate rate." This action somewhat improved the situation, as interested

TABLE 1

Rate Schedules in United States

Monthly Consumption *cu m*	No. of Water Works	Rates—*cents*			
		Min.	Max.	Mean	Median
0– 8	416	0.71	38.0	6.8	6.2
28– 280	416	0.70	16.7	5.1	4.5
280–2,800	413	0.43	9.0	3.2	3.0
more than 2,800	404	0.20	9.0	2.8	2.5

parties could foretell whether their proposed rates would be approved by checking them with the figures that would be obtained by the official method. The system provided equity, however, only when the proposed rates, as approved by the municipality, were too high or unjustly distributed. But most municipalities have no engineering advice, and, when water rates are submitted for approval, they still use state water works rates as a standard. Thus, the approved rates are usually insufficient to meet all the requirements of a modern water service. It would be quite unfair, though, to expect the National Sanitary Commission to increase rates that are apparently satisfactory to both the grantee and the municipality.

The present practice of the National Public Service Commission is to approve or disapprove on the merits of each individual application. An inadequate rate approved by the municipality and brought to the attention of the commission, however, is not likely to be declared inadequate unless the interested party has recorded a complaint, which action he rarely takes. New water works can expect more favorable rates, but existing private utilities that currently operate with insufficient rates will experience greater difficulty in obtaining adjustments. Many of these existing water works have filed petitions with the National Public Service Commission to raise rates and have obtained approval, but a superior board, set up during the war, must also pass on water rates and its policy has so far been to make no changes.

Comparison With U.S. Rates

Cost data and water rates for a large number of water works in the United States as given in the JOURNAL (1) are presented in Table 1, in which the rate figures given in thousands of cubic feet have been converted to cubic meters. The average rate for industrial purposes is 2½–3¢ per cu m. These values, of course, refer to metered supplies. The highest rates apply to users of less than 45 gpcd on the basis of six persons per connection. The smaller water works are in this group. The next category has an average consumption approaching 200 gpcd on the same basis. This amount is considerably greater than that provided by any Cuban water works except that of Marianao. Mean and median rates in the United States applying to monthly consumptions which are similar to those of Cuban water works, therefore, are: mean: 5.1–6.8¢ per cu m; median: 4.5–6.2¢ per cu m.

The average flat rate for medium to large Cuban water works is approximately $24 per year. The small water works charge half as much. The structure of the flat water rates, however, varies so widely that a fair comparison with the metered supplies in the United States cannot be made. Most Cuban water works also set a price per cubic meter which corresponds generally to what is paid on an average flat rate. The price is: mean: 3.1¢ per cu m; median: 2.9¢ per cu m. A comparison of these rates with equivalent values in United States is given in Table 2, which shows that Cuban water works charge approximately half as much as those in the United States.

Profit Situation

It has been argued that the lower cost in Cuba corresponds with the low quality of the service. With the exception of filtration, which is not required for deep well water—the source from which most small to medium Cu-

ban water works obtain their supplies —other operating expenses such as pumping, administrative, capital, and similar charges must be met. Although the installations in many aspects are not the equivalent of their American counterparts, the cost of the works and the cost of pumping are much higher in Cuba. The cost of pipe, which comprises not less than 75 per cent of the total cost of a water works even if filtration is required, is approximately 40 per cent more in Cuba than in the United States. The same situation is true for pumping equipment, valves, and accessories.

In figures on the finances of fifteen important Cuban water works recently published (2), it is revealed that water works operated by the Cuban Electric Power Co., among the few that provide efficient service, show an annual loss even without taking capital charges into account. This company's chief interest is to produce power during the slack hours and to show a good profit in the power business. The Marianao water works, which serves a population of more than 130,000, gives only a 4 per cent return on an investment of approximately two million dollars, primarily because of the high cost of power. Extensions and revamping of the system which is valued at more than the supposed original investment are soon to be financed by the central government.

The city of Santiago de Cuba with a population as large as that of Marianao has a state-built water works. The investment to date is more than eight million dollars. The statements show an excess of income over expenditures of only 1.2 per cent on the investment. Filtration is needed but is not provided, although plans for its introduction have been approved. Private water works cannot possibly improve their plants. Profits that are extracted can come only from deferring badly needed extensions and improvements.

Necessity for Adjustments

If modern and efficient water supplies are to be obtained, the right of private water works to receive substantial rate increases must be recognized, and the law must be amended to make possible spending a certain proportion of the total revenue on extensions and improvements. This obligation is already recognized in regulations enforced by the National Public Service Commission, which permit such expenditures to the extent of 25 per cent of gross income.

TABLE 2

Comparison Between Cuban and United States Average Rates

	Price—*cents per cu m*	
	Mean	Median
Cuba	3.1	2.9
U.S., *range*	5.1–6.8	4.5–6.2
U.S., *gross avg.*	5.9	5.3

Water is an essential commodity which, under the law, every Cuban owner must provide free of charge to his tenant. According to the sanitary department, the water must be pure and potable. The wealthy, who pay $80 a year per family for bottled water, have this type of water. To this figure is added the average $24 per year paid for water for other purposes. Thus the wealthy spend $104 per year for their own water but pay only $24 for that which they provide for their tenants.

If the public water supply is not of the right kind because those who pay for it are not willing to contribute to its improvement, it would appear that they should be willing to provide their tenants with the same kind of water that they enjoy. Landlords, of course, reply that the amounts they collect from tenants in rent include only what is paid for the present water supply—an increase in their contributions to water supply improvement will necessitate rent increase.

House owners expect not less than 6 per cent return on their investments —considerably more than water works obtain. If the utilities are required to absorb the costs for improvements, nothing will be left as profit. It seems, therefore, that the water works should be the only party not required to contribute to the cost of necessary improvements. Pure water in Cuba does cost much more than the current legal rate can provide. Pure water is, however, the only kind that can be accepted for home consumption.

On the other hand, whatever the problems of costs and rates, water supply should be handled as local matter, paid for by those who receive the benefit. The intervention of the government has proved to be most unfortunate and should be discontinued. It has been a detriment to responsible citizenship. As matters now stand, any expenditure on municipal work appears too costly to the taxpayers, as a comparison is made with the cost for the same work when done by the government—which, of coure, appears statistically to be nothing.

No judgment is rendered here whether the owners, the tenants, or both should pay for the badly needed improvements in Cuba's water works. As matters stand, however, the utilities should not be asked to contribute while they continue to operate on a 30-yr grant basis and charge an average rate of $2 per month, or approximately 3¢ per cu m.

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Corrosion History of a Domestic Hot Water System

By John R. Baylis

A contribution to the Journal by John R. Baylis, Engr. of Water Purif., Bureau of Eng., Chicago.

THE hot water system of a newly constructed house into which the author moved in March 1928 consisted of a 30-gal galvanized iron tank (12 in. in diameter, 5 ft long); a gas-fired, copper-coil heater mounted beside the tank, and another heating unit in the furnace (Fig. 1). The furnace supplied much of the heat in the winter months; in summer it was all produced by the gas heater. No attempt was made to keep the water in the tank hot continuously when the furnace was not in use. The tank was connected to the two heaters and to the house plumbing by ¾-in. galvanized iron pipe. The tank wall was approximately 0.08 in. thick.

Appearance of Rust Holes

Available evidence indicates that there was active corrosion in the system for years, but no accelerated activity in such periods as that following construction of the South District Filtration Plant. Between the fourth and sixth years that the system was in service, a small leak appeared in the upper part of the front side of the tank, 7 in. from the top. From time to time a small amount of water accumulated on the outside of the tank at the leak —sometimes enough to flow down the side of the tank to the floor. It was planned to drive a plug into the hole, in accordance with common practice, if it ever became large enough to permit a free-flowing leak, but plugging was never required.

A year or more later, another leak appeared and was followed by others, until, when the tank was removed in October 1950, twelve had been seen from the outside. No leak developed into a free-flowing stream, although, at times, leakage from one hole or another was sufficient to wet the basement floor to a drain 12 ft away.

The leaking spots always healed after periods of leaking. A number of them were usually dry, whereas others were moist most of the time. The tank was removed primarily to examine the state of the inside after 22½ year's service. Its expected life was already exceeded by several years.

Examination of Interior

When the tank was cut open with a torch, all the large tubercles on its wall were dislodged, falling into a pile on the inside. Most of the large tubercles had broken into 1–6-in. long pieces. No difficulty was encountered in finding where many of the pieces originally fit on the tank wall. Effort was made to restore three or four of the longer tubercles, as shown on the right side of Fig. 2. The replaced tubercles, fastened to the tank with clay, were easily recognizable to the eye but did not photograph well because of the dif-

ficulty in distinguishing between the clay and rust on a picture. The cold water inlet pipe inside the tank is shown in the left side of Fig. 2; the opposite side of the pipe is largely eaten away by corrosion. The inside surfaces of each half of the tank are shown in Fig. 3 after the tubercles were removed. The cold water pipe had also been removed before the photograph was taken. The dark spots indicate where tubercles had formed. The rest of the area is the galvanized surface of the tank—still in good condition. Chemical analysis of a sample scratched from the tank wall shows that it is largely zinc, with some calcium and magnesium present. Where corrosion is most extensive, in the upper part of the tank, the zinc shows a tendency to blister in places.

Several long, finger-like tubercles, one of which reached a length of 30-in., had formed. Pieces of paper were rolled into small cylinders and placed into most of the holes to facilitate reading of the photograph. A sharp pointed tool was used to locate and also to clean around the holes. The first leak that had appeared in the tank was at the top of the longest tubercle. The order in which the other holes appeared is not remembered, although it is believed their ages were in approximate proportion to the length of the tubercles attached.

Figure 4 is an enlarged view of the parts of the tank wall at which corrosion was greatest.

Heater Pipe

The $\frac{3}{4}$-in. hole approximately 6 in. from the top of the right side of the tank, shown in Fig. 3, was the hot-water inlet from the heaters. The cold water left the tank through a pipe, on the front side near the bottom, to the gas heaters, then flowed upward and into the tank near the top. The furnace-heater connection was at the bottom of the tank. The furnace-heater discharge pipe was connected to the discharge pipe from the gas heater by a T-joint. Tuberculation occurred in the piping from the furnace heater to the hot water tank but was not serious enough to interfere with the flow of water. Hot water was withdrawn through a $\frac{3}{4}$-in. pipe connected to the pipe in the tank.

Peculiar Corrosion of Inlet Pipe

The $\frac{1}{2}$-in. galvanized-iron cold-water pipe inside the tank extended from the top of the tank to within 6 in. of the bottom. The cause of corrosion of the outside of the $\frac{1}{2}$-in. pipe did not affect the inside pipe surface, as no rust tubercles of any considerable size were noted there. One exterior rust tubercle extended down the full length of the pipe. To remove this pipe it was necessary to cut it off with a hack-saw near the top of the tank. The bent stud, approximately 2 in. long, shows at the top of the left half of the tank (Fig. 3).

In Fig. 5 are shown three views of the $\frac{1}{2}$-in. cold-water pipe, after the long rust tubercle was removed. The center of the pipe was $1\frac{3}{4}$ in. from the center of the tank. As shown in the top view, the side of the pipe nearest the tank wall was corroded away along its entire length. For approximately two-thirds of the length from the top down, the pipe surface was perfect, with the galvanizing still in place. Near the lower end of the pipe, the rust tubercle extended entirely around the pipe, and at another place, for a distance of approximately a foot, it extended almost entirely around the pipe.

The most puzzling characteristic of this corrosion is that it was confined

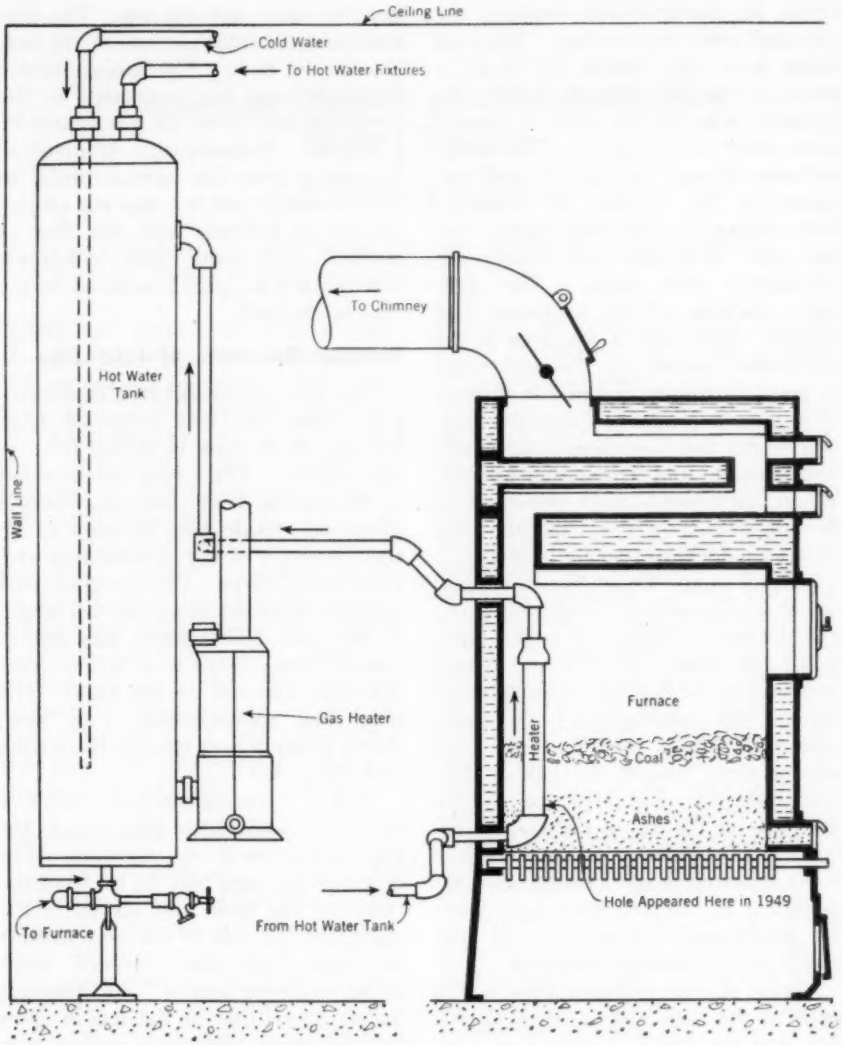

Fig. 1. Arrangement of Hot-Water System

Tank is galvanized iron, 12 in. in diam, 5 ft long; gas heater provided heat when furnace was not in operation.

to one side of the pipe. Except for the fact that this side was closer to the tank wall, no reason for the one-sided corrosion can be given. The cold-water pipe was in its proper position—not sloping at the lower end toward the tank wall. The 5½-ft tubercle, remained intact until after the tank was cut open. The location of this pipe in relation to the tank wall

evidently had some influence on the manner in which the corrosion took place. No relation was found between the long tubercles on the tank wall and the one on the pipe. An explanation of the cause of this kind of corrosion would add greatly to knowledge of hot-water corrosion.

Cause of Finger-Like Tubercles

The apparent downward growth of the finger-like tubercles is another unexplainable feature of the corrosion on both the pipe and the tank wall. Such growth is generally not a characteristic of cold-water corrosion where tubercle formation occurs. Possibly the coatings formed by tubercles in hot water may not be as impervious as cold-water tubercles. In hot-water corrosion, escape of the soluble products from the inside of the tubercle may be through numerous pores instead of through an occasional well defined break in the impervious membrane as in cold-water corrosion. Also, concentration of negative ions, such as the sulfate ion, may not be as great in hot water as it is in cold water.

The lower ends of the finger tubercles are almost as hard as any other part. Such a condition would not seem likely if growth were continuous in one direction. Yet it is difficult to imagine a 1-ft or longer finger tubercle forming spontaneously. As the 30-in. finger tubercle was corroding actively enough to pierce the tank metal fifteen to seventeen years before removal of the tank, the corrosion must have started two or three years before that. Undoubtedly it started when the zinc developed a pinpoint hole, which, in time, enlarged. As shown in Fig. 3, either the tubercle started 2 or 3 in. above the hole or another tubercle developed from above to join with the longer one.

Examination of the finger tubercles demonstrates convincingly that growth was downward. At the lower end of each tubercle, for a distance of ¼ to 1 in., the zinc coating, although covered by the tubercle, had not corroded. Apparently intermittent discharges of the soluble iron products from the tubercle occurred, forming precipitates of ferric hydroxide which would cover the area of the zinc-coated wall at the lower end of the finger. The acid inside the tubercle eventually corroded the zinc coating. Figure 3 shows a rounded white streak at the lower end of the 30-in. tubercle. For a distance of ¼ in. or more, the corrosion had not dissolved the zinc coating, indicating a rather recent extension of the tubercle. The slightly darker streak extending 2 or 3 in. beyond the lower end of the tubercle is a reddish iron precipitate not thick enough to form a real coating over the zinc. This streak indicates, however, that much iron precipitate settled at the bottom.

In Fig. 3 the dark areas that show the locations of the tubercles may be somewhat confusing in the photograph of the front half of the tank, because the clay used in an attempt to fasten the tubercles back on the metal surface left streaks along the location of some of the finger tubercles which look darker than the galvanized surface of the tank.

The upper and lower ends of the tubercles vary little in size, although the upper ends of the long tubercles must have formed years earlier than the lower ends. Possibly the downward growth may be a result of diffusion of the iron salts through the lower end of the tubercles, the force of gravity tending to cause settlement of the iron precipitate that results from union of the salts with the alkalinity in the water. Without more evidence, how-

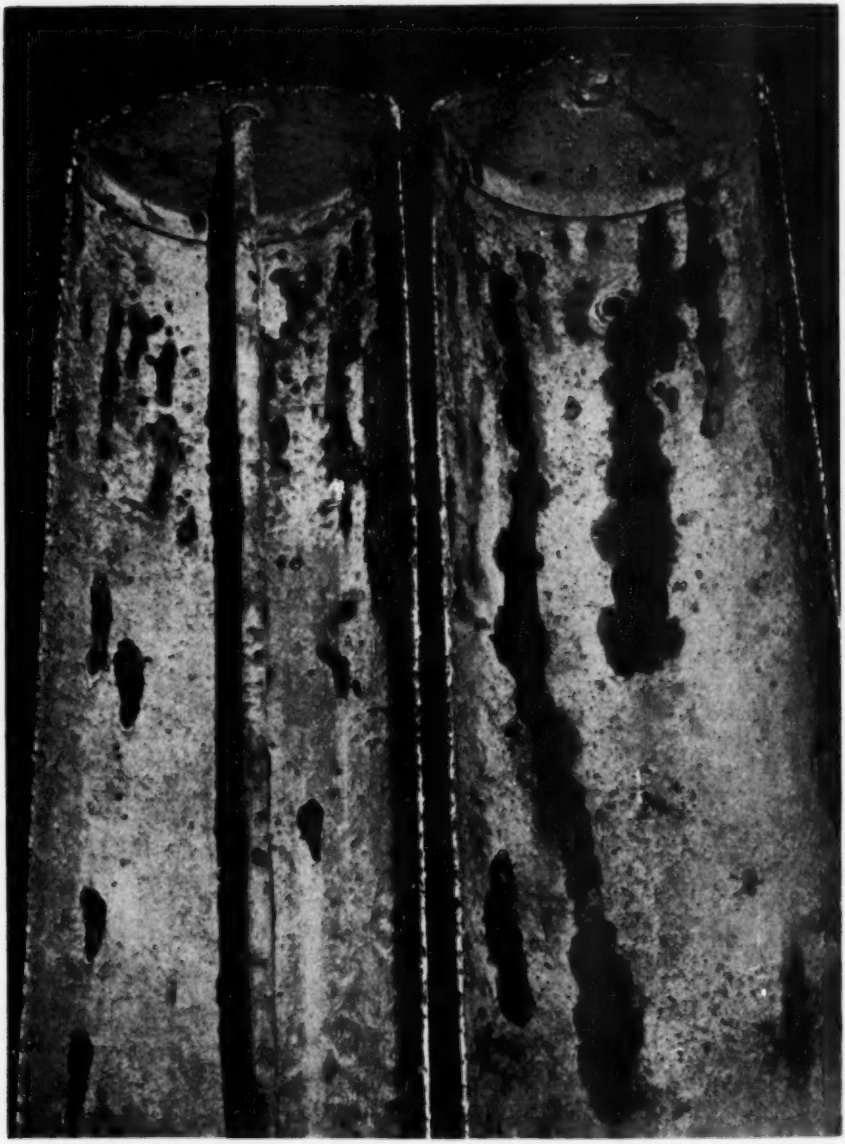

Fig. 2. Inside of Hot-Water Tank After 22½ Years of Service

Pipe in left half of tank is ½-in. galvanized-iron, cold water inlet. The long, dark streak in the right half is a 30-in. tubercle replaced in its original position by fastening with clay.

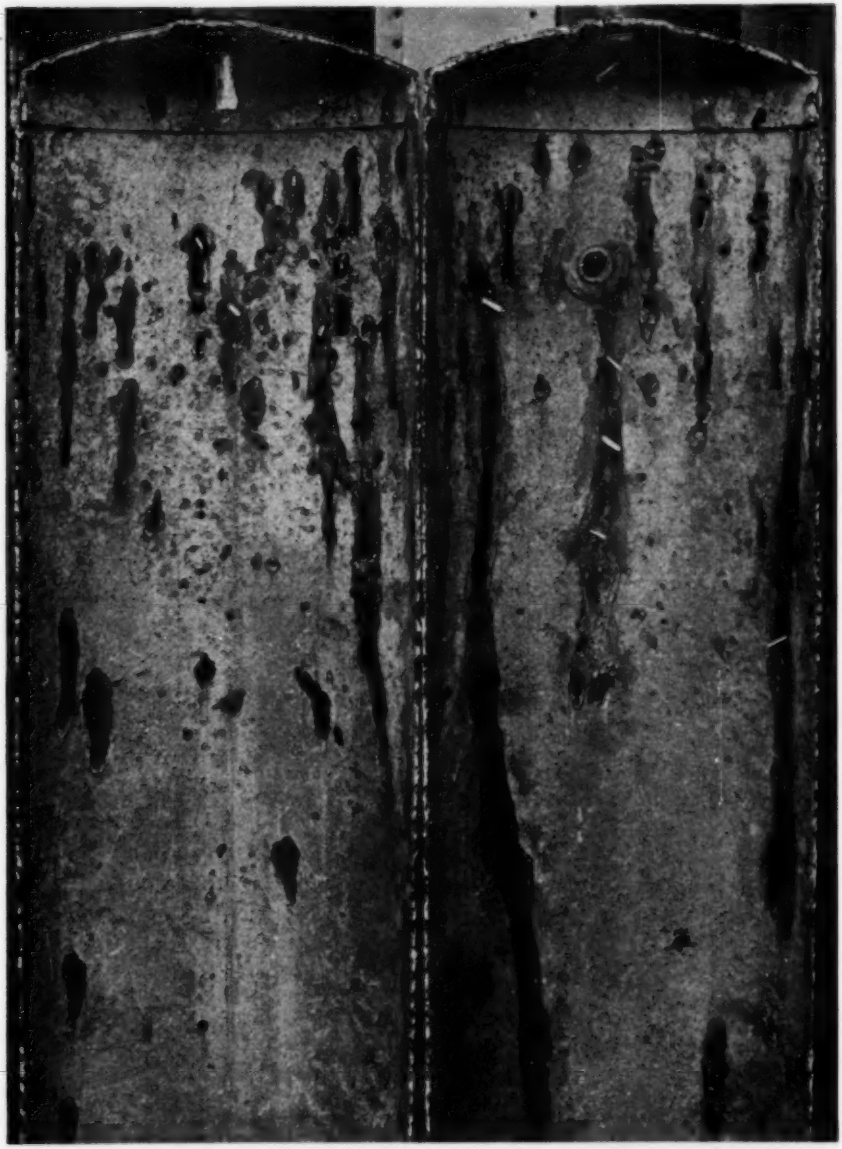

Fig. 3. Inside of Tank Shown in Fig. 2, After Tubercles Were Removed

When tubercles were removed, cylinders of paper were inserted in holes in tank wall. Left half in photo is referred to as "back half" because it was nearest the wall of the house; right half is "front half."

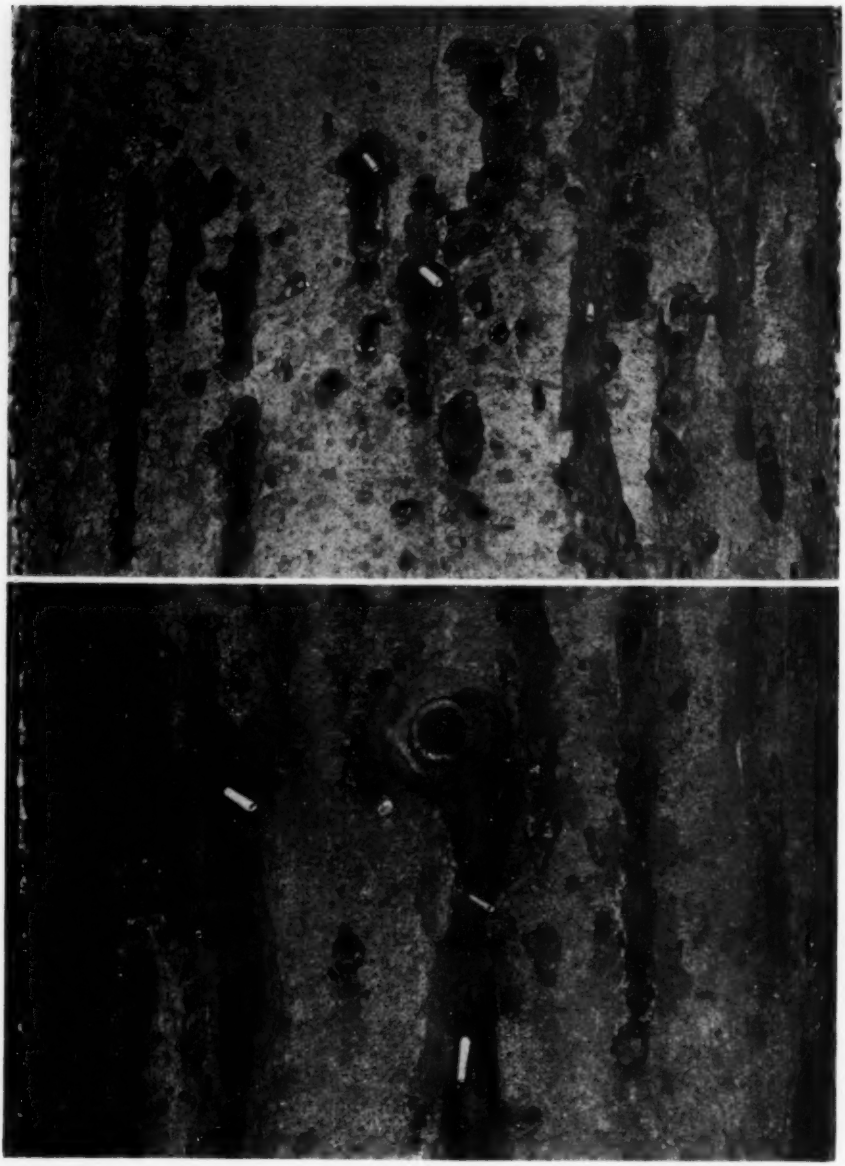

Fig. 4. Close-up of Sections of Tank Wall Showing Greatest Corrosion

Top: *Section near top of back half of tank;* Bottom: *Section near top of front half, around hot water entrance.*

ever, such an assumption cannot be accepted as a fact. The significant point is that finger-like tubercles of great length were formed on the inside of the hot-water tank.

Twelve Self-Sealed Holes

Eleven of the twelve holes were located in the upper part of the tank, 2–18 in. from the top. When the rust was scraped out, the holes were found to vary from $\frac{1}{8}$ to $\frac{1}{4}$ in. in diameter. Most of the holes can be easily located in Fig. 3 by the rolled pieces of paper stuck into them. The approximate location of a hole was determined from the outside wherever evidence of leakage through the wall was found. The area was prodded, both inside and outside, with a pointed hand tool until the hole was found. The rust, which was usually quite hard, was cleaned from the iron surface near the hole. The hardness of the rust was obviously what prevented the water from coming through the tank wall in a free-flowing stream.

The escape of a small amount of water through the hole apparently washed away the concentration of negative ions within the area and stopped the action of such ions as those of sulfate on the metal surface near the hole. Then long periods in which no leakage occurred would follow.

Figure 6 shows a $\frac{3}{16}$-in. diameter hole rusted through the wall of the tank. It is easy to locate this hole in Fig. 3 by its relation to the weld seam. Within a radius of almost $\frac{3}{4}$ in. around the hole, the tank wall was eaten away until it was practically paper-thin. Evidence indicates that a blowout approximately $\frac{1}{2}$ in. in diameter was imminent. A number of places at which the wall was nearly pierced and two or three where the tool actually pierced the wall into a well defined hole gave no outside evidence of leakage.

Pitting and Tuberculation

Pits with overlying tubercles are believed to form in hot-water corrosion in the same general manner as in cold-water corrosion. A hard crust that is practically impervious to water forms near the surface of the tubercle. Attempts to photograph this impervious layer failed to reveal the black layer, for red and black are indistinguishable when photographed in black and white. A low-power microscope revealed that the layer which forms over a tubercle in the hot-water tank is not as solid as the layer over a cold-water tubercle.

Figure 7 shows a segment of a finger tubercle that was removed from the tank. A white streak can be seen near the outer edge, and the very porous nature of the inside of the tubercle can be recognized. The top part of the tubercle in Fig. 7 was the surface in contact with the lower part of the metal surface. The lower part of Fig. 7 is a view of the inside surface of the tubercle. The substance forming the white streak was not determined, but when it occurred, the streak was found just inside the black layer. As it was on the acid side of the nearly impervious layer, it could not be calcium carbonate. It could, however, be ferrous carbonate, ferrous sulfate or some more insoluble product or, perhaps, a zinc compound. The white appearance was not noticed until the tubercle was dried.

In accordance with the theory of corrosion, iron enters solution at the metal surface as ferrous hydroxide, which may be quickly converted into an iron salt such as ferrous sulfate. The soluble product diffuses slowly

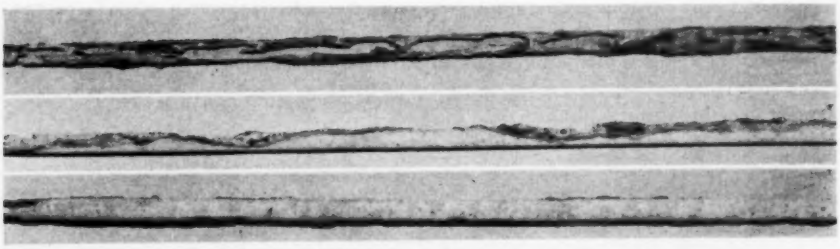

Fig. 5. Three Views of Badly Corroded ½-in. Cold Water Pipe

Photographs taken after long rust tubercle was removed. Top view is from back; center, from side; and bottom, from front.

through the porous material to the outside of the precipitate. When first formed, the precipitate is quite soft and porous. The solution containing soluble iron comes in contact with the water containing alkalinity and is converted into ferrous hydroxide. As soon as it diffuses to the zone of dissolved oxygen in the water, it is converted into highly insoluble ferric hydroxide. The flow of electric current in the corrosion cell is such that the acid ions, after liberation from the ferrous ions, are drawn toward the metal surface. At the metal surface, the acid ions again unite with ferrous hydroxide. They enter solution at the metal surface electrochemically to form more ferrous sulfate.

If the iron salt is diffusing to the surface of the ferric precipitate quickly enough to keep the zone of zero-dissolved-oxygen extending into the water beyond the precipitate, the porous oxide of iron precipitate will continue to increase in size. Most of the iron rust probably floats away in the water and has no effect on enlarging the tubercle; enough does adhere to that already precipitated to enlarge the tubercle, gradually building it up from the outside. When the dissolved-oxygen zone extends to the surface of the precipitate, the oxygen begins to convert the soluble iron at the surface into ferric hydroxide and gradually forms an impervious membrane that may stop corrosion.

The growth of the tubercle is not effected by pushing the already deposited material away from the metal surface but by diffusion of soluble iron salts from the metal surface to the water surrounding the tubercle. There the tubercle comes in contact with water containing alkalinity and dissolved oxygen and forms a ferric hydroxide. Some of the precipitate is attracted back to the tubercle, and causes it to grow, much as a brush pile grows as laborers throw more brush upon it. Formation of pits with overlying tubercles is explained elsewhere (1, 2).

Temperature evidently has some influence, for there was more corrosion in the upper part of the tank, where the temperature was higher. The higher temperature may cause flow of electric currents strong enough to aid corrosion along the path of the current. With a metal-to-metal connection at the top of the tank, such current would encounter difficulty in passing through the water.

Local Conditions

Lake Michigan water is considered noncorrosive. At temperatures of 32–

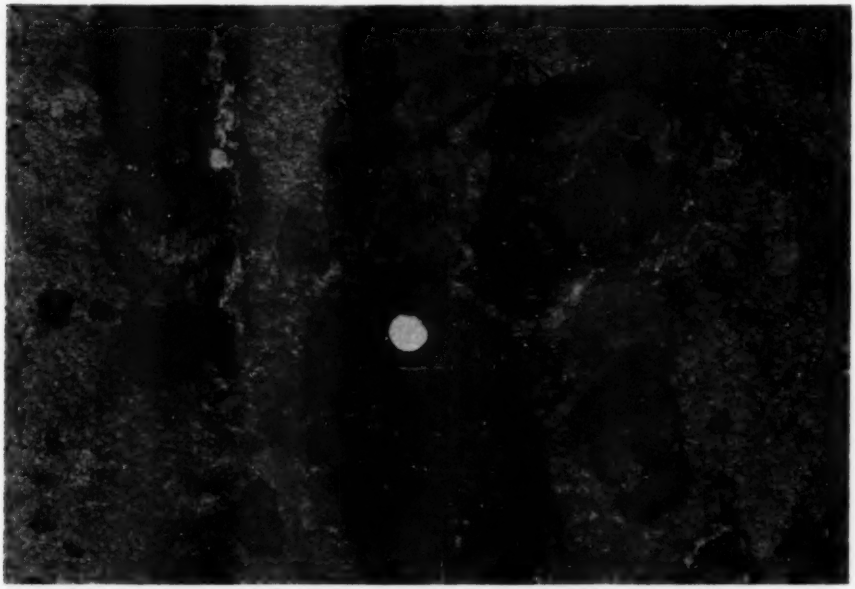

Fig. 6. Exact-Size View of a Hole in the Tank Wall, Showing Badly Corroded Surrounding Area

Hole is shown near top of back half of tank in Fig. 3, where location can be determined by position of weld seam.

75 F., the water is saturated with calcium carbonate. It also is saturated, or nearly saturated, with dissolved oxygen. A water supersaturated with calcium carbonate will gradually form a layer of calcium-carbonate incrustation on pipe surfaces and other surfaces in contact with the water. If the water is not saturated, it will dissolve calcium carbonate—slowly if slightly below the saturation point and rapidly if considerably below it. Heating water to a temperature near boiling appears to lessen its solubility. Consequently, when in contact with Lake Michigan water, heat-exchange units, such as copper tubes in heating boilers, are generally incrusted on the inside with calcium carbonate.

In individual homes, the water in the hot-water tanks is often maintained at a temperature below that which will cause a deposit of calcium carbonate on the tank and pipe surfaces. Clogging occasionally develops in the heating coil and in the furnace heater. The rate of scale buildup, however, is slow. During their 23 years of service, the heating units discussed here did not clog seriously.

In a hot water system in which the tank, heaters and piping are made of galvanized iron, corrosion or incrustation is to be expected. Fifteen years is considered a satisfactory service period for heaters that use noncorrosive Lake Michigan water. In some of the cities with more corrosive waters, ten years is considered a good life. Newell (3) states that the presence of traces of copper causes increased corrosion in galvanized hot-water stor-

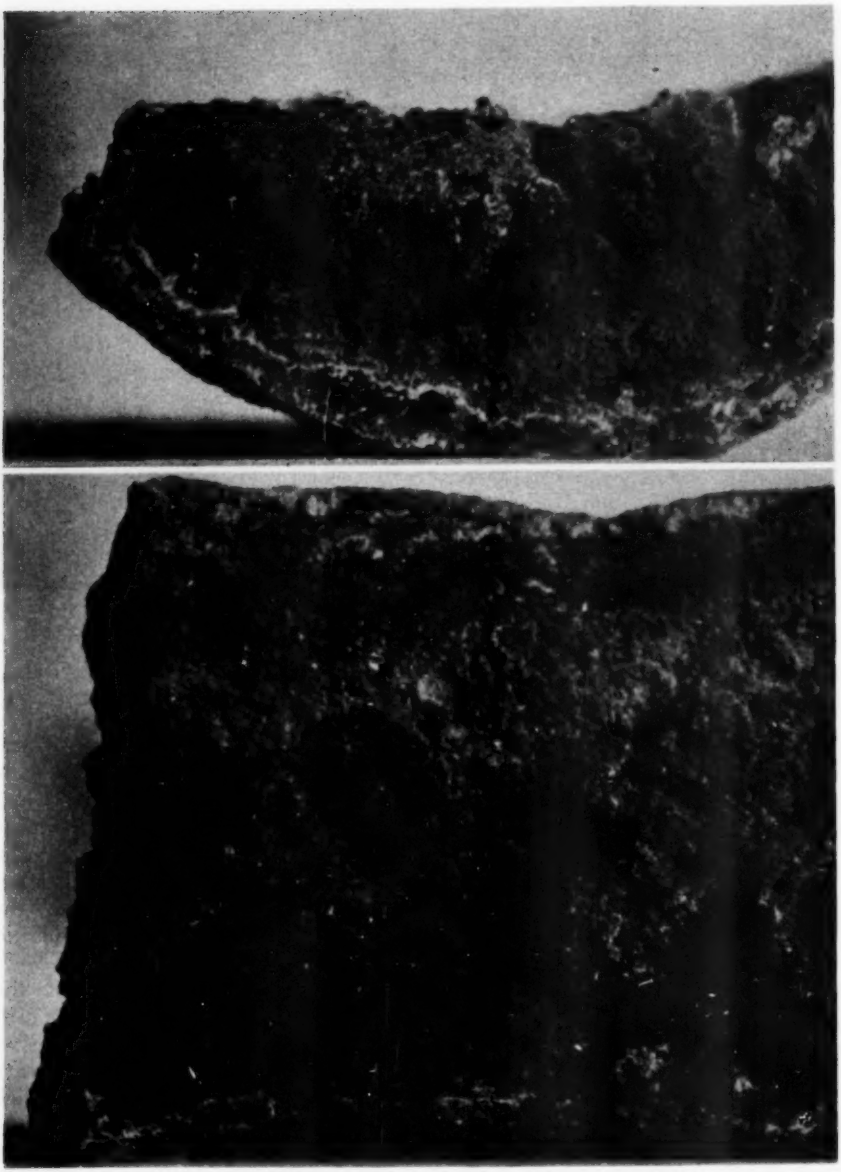

Fig. 7. Section and Inside Face of Finger Tubercle

Top: *Section of tubercle, photographically enlarged 4.0 ×;* Bottom: *Inside face, magnified 2.7 ×.*

age tanks. Temperatures of more than 140 F. may cause the zinc to become cathodic to iron. He believes the corrosion may be lessened by using systems with no copper and by fabricating the piping from aluminum brass.

Had the lake water contained only 2–3 ppm of calcium carbonate in excess of the saturation equilibrium, a coating of calcium carbonate probably would have formed. This coating would have developed to $\frac{1}{32}$–$\frac{1}{16}$ in. in thickness during the 23 years of use. Opinions differ on which lake water is more satisfactory—that saturated with calcium carbonate or that supersaturated 2–3 ppm. To the author, the slight excess seems preferable. The excess, however, should not be sufficient to cause incrustation to collect in the water meters throughout the distribution system.

The hot-water heaters shown in Fig. 1 consisted of a copper coil, heated by a gas burner and hand controlled, and a heating unit in the furnace. The gas heater was mounted on the side of the hot-water tank. Heating the water in either or both the units produced a flow through the heater caused by the difference in weight between hot and cold water.

Fig. 8. Close-up of Inside of Copper Tube in Gas Heater

No corrosion and very little incrustation is shown despite 22½ years in service.

After 22½ years of service, the gas heater was removed at the same time as the tank, in October 1950. It had never given any trouble and could have been continued in use if necessary. A section of the coil, with part cut away for examination, is shown in Fig. 8. Two sections were removed, one near the lower part of the heater and the other near the top. Surprisingly, the heater contained no corrosion and very little incrustation.

During the winter months, when the furnace was in use, the gas heater was used to heat only bath and laundry water. It was used on an average of twice daily for periods of fifteen minutes to an hour. During the summer months, when there was no fire in the furnace, the gas heater was used several times daily and was occasionally left on for two or three hours. Thus, the gas heater was usually in contact with cold or only slightly heated water.

The ¾-in. galvanized iron pipe connected to the top of the gas heater was in perfect condition to the point at which it was connected with the piping from the furnace heater. A slight rust tubercle occurred at the lower end of the pipe where it was cut and an iron surface was exposed to the water. All of the piping was in good condition.

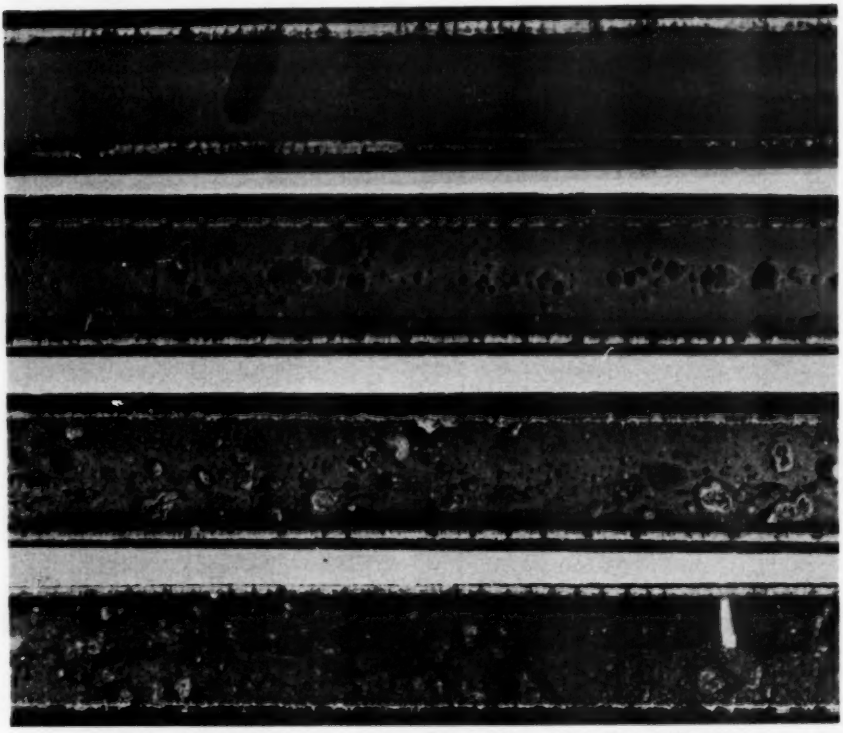

Fig. 9. Copper Tubes From Apartment House Hot Water Heater

Tubes are ½ in. ID. Heater was approximately 8 years old when removed. The two bottom tubes are from bottom of heater; next is from the center; and the top one from the top of the heater.

Furnace Heater

The furnace heater was a piece of extra heavy 1¼-in. black pipe, 11 in. long, threaded at both ends and connected by reducers to ¾-in. galvanized iron pipe. The elbow and reducer were also heavyweight black iron. The heater was located so that a really

hot fire would not come in contact with its full length. Generally, the ashes in the furnace were allowed to build up about the bottom of the heating unit to decrease the area exposed to the fire. The furnace was coal-fired without stokers and was ordinarily operated at a temperature below which clinkers are formed. This heater failed after 21 years of service from extensive corrosion that formed at the outside near the lower end. Upon removal, it was found that a small amount of incrustation had formed on the inside of the heater and piping and that there was some tuberculation of the pipe. At joints where the pipe was cut and threaded, evidence of corrosion was generally found. The tuberculation probably retarded flow slightly, although there was no noticeable loss of efficiency.

Heater-Tube Corrosion in Apartment Buildings

A sixteen-tube boiler type water heater taken from an apartment building in Chicago was recently removed because of leakage in the tubes after only a few years use in heating the filtered water of Chicago. This type of copper tube-heater, in which eight double-rows of tubes are fixed one above the other, tends to corrode readily. The condition of tubes from a similar heater, removed and split, is shown in Fig. 9. The two lower views are of tubes from the bottom of the heater; the tube shown next to the top was located near the center of the heater; and the top tube shown is from the top of the heater. Severe corrosion is noticeable in the bottom tubes, slight corrosion near the center of the heater and none at the top. The inside surfaces of a tube located in the upper part of the heater was coated with a layer of calcium carbonate, $\frac{1}{32}-\frac{1}{16}$ in. thick.

Corrosion protection of the copper was effected entirely by the precipitate that was formed on the metal surface. The copper coil in the household heater was only partly covered with a coating. It would be interesting to know why one corrodes so severely and the other not at all.

Evidence indicates that some influence other than the natural tendency of the metal to corrode is aiding the corrosion. This influence appears to aid in the corrosion of copper, brass and galvanized iron surfaces. The immediate problem is to determine its nature and some means of measuring it. Only when such a determination is made may some means of controlling the corrosion of metal pipe and hot-water tanks be developed.

Summary

1. The condition of a hot water tank after $22\frac{1}{2}$ yr of use is described.

2. The tank was galvanized iron, 30-gal capacity, with metal thickness of 0.08 in. It was connected to a furnace heater and to a gas heater.

3. Holes appeared in the tank from time to time, the first appearing approximately 5 years after installation.

4. None of the holes developed into free-flowing streams and therefore they did not require repair. Once formed, however, the holes leaked intermittently.

5. The rust tubercles on the inside wall of the tank were largely finger-like, the longest measuring 30 in.

6. The $4\frac{1}{2}$-ft length of cold water inlet pipe had a rust tubercle along one side of the outside for the full length of the pipe. The opposite side of the pipe was in perfect condition.

7. Cause of the development of the tubercles is not known although it may

be the tendency of the precipitate from the tubercles to settle.

8. There is strong evidence that the tubercles grew downward.

9. Pits with overlying tubercles appear to form in the same general manner in hot water as in cold water.

10. The gas heater with copper coils showed no corrosion.

11. The furnace heater, made of black-iron pipe, failed after 21 years of service because of outside corrosion. A coating of calcium carbonate formed on the inside.

12. A few tubercles were found in the hot water piping between the furnace heater and the tank. These tubercles were more prevalent at joints where the pipe had been cut, thus exposing an iron surface.

13. Boiler type heaters with straight copper tubes corrode badly and depend on the formation of a coating of calcium carbonate to protect the copper.

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Correction

In the paper "Flural—A New Flocculating-Fluoridating Agent" by Wayne E. White, Jack C. Gillespie, and Otto M. Smith, which appeared in the January 1952 JOURNAL, the value for k in the equation which appeared on p. 72 was incorrectly given as 0.0209. The correct value for k is 0.00122.

Modified Zirconium-Alizarin Reagent for Determination of Fluoride in Water

By Stephen Megregian and Franz J. Maier

A contribution to the Journal by Stephen Megregian, Sanitarian (R), and Franz J. Maier, San. Engr. Director, both of the Div. of Dental Public Health, U.S. Public Health Service, Washington, D.C.

THE fluoridation of public water supplies for reducing the incidence of dental caries has created a need for a simple, accurate method for making routine determinations of fluoride concentration in water. An accurate determination can be made by a controlled distillation process which is time-consuming and difficult (1). Many direct colorimetric methods have been developed to estimate fluorides in water. The more accepted ones are based on the reaction of zirconium and alizarin to produce a lake which is decolorized by the fluoride ion.

The present standard method (1) using the zirconium-alizarin color reaction was developed by several investigators, beginning with DeBoer (2) and followed by Elvove (3), Sanchis (4), and Scott (5, 6). The evolution of the method has been characterized by changes in the reaction conditions and acid concentrations. None of the investigators except DeBoer published the experimental basis for recommended ratios of zirconium to alizarin. Although the reagent was improved considerably in its ability to reduce sulfate and chloride interferences and to shorten the reaction time, some of the principal shortcomings of the reaction, such as nonconformity to the color laws, limited effective fluoride range, and little color change per increment of fluoride, were not significantly improved or eliminated. Todd (7) and Taras (8) applied the standard method to spectrophotometric study and pointed out these deficiencies.

Experimental Procedure

The purpose of the investigation described here was to improve the standard method for fluorides by modifying the reagent. Except when visual methods were employed, color comparisons were made with a Beckman Model B spectrophotometer. Most of the observations were made using a 70-mm special cell in order to utilize the longest practical light path with this instrument.

Preliminary experiments revealed that when the ratio of alizarin to zirconium was greater than required by the standard method, there was considerable increase in the total color developed and a greater color change per unit of fluoride. Figure 1 shows the effect of alizarin concentration on the color produced in the zirconium-alizarin reaction. The readings were taken after the reagent, prepared with Scott's mixed acid,* was allowed to

* Scott's mixed acid is prepared by diluting 37 ml concentrated H_2SO_4 to 500 ml, 112 ml concentrated HCl to 500 ml, and mixing to make 1 liter. To prepare the final reagent 900 ml of the mixture is used. In the above studies, the alizarin was always made up and kept as a separate solution and the zirconium was made up with the appropriate amount of mixed acid. By keeping the reactants separate, aging errors are eliminated.

react for 60 min at room temperature with distilled water in the same manner as in a standard fluoride determination.

The color increment per unit of fluoride for each of the various ratios of alizarin to zirconium was next determined and plotted as indicated in Fig. 2. From these curves it is evident that the ratio 7.5 to 1.0 by weight gives the greatest color increment per unit of fluoride, provides a satisfactory range of fluoride concentration, and produces

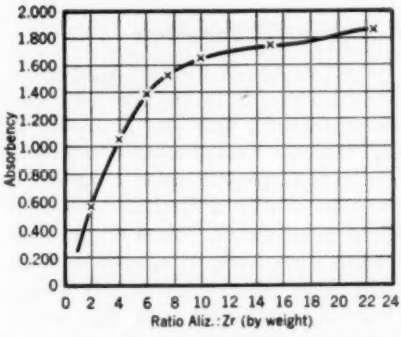

Fig. 1. Effect of Alizarin Concentration on Color Production of the Zirconium-Alizarin Reagent

Zirconium content was 0.5 mg per 100 ml; reaction time, 60 min; light path, 7 cm; and wave length, 525 mμ.

a standard curve which follows Beer's law. Increasing or decreasing the concentration of zirconium and alizarin in the reagent has the effect of increasing or decreasing the total color production without any appreciable change in the absorbency per unit of fluoride. Higher fluoride concentrations (more than 4.0 ppm) can be determined by increasing the amounts of zirconium and alizarin in the reagent.

In Boonstra's modification of the standard method (9), an alizarin-zirconium ratio of 22.5 to 1.0 by weight is recommended. The curve shown in Fig. 2 indicates that this ratio falls below the maximum sensitivity for fluorides.

On the basis of these observations, the following method was selected as most suitable for the spectrophotometric determination of fluoride in water. The extinction per centimeter of

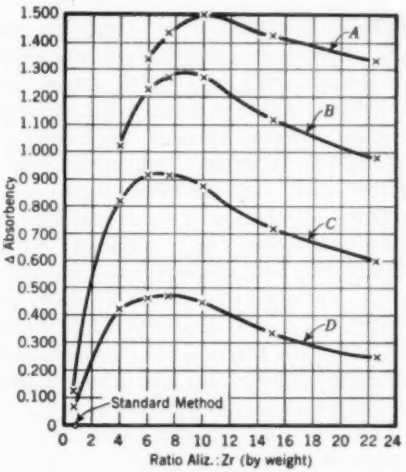

Fig. 2. Change in Absorbency per Unit Fluoride for Various Weight Ratios of Alizarin to Zirconium

The zirconium content was 0.5 mg per 100 ml; reaction time, 60 min; light path, 7 cm; and wave length, 525 mμ. The fluoride increments were: for Curve A, *0.0–4.0 ppm; for Curve* B, *0.0–3.0 ppm; for Curve* C, *0.0–2.0 ppm; for Curve* D, *0.0–1.0 ppm.*

light path per part per million fluoride in the range of 0 to 3.0 ppm fluoride is approximately 0.070, thus making it possible to determine fluoride residuals accurately to 0.10 ppm using 1-cm cuvettes and to make readings of 0.02 ppm easily with cells of longer light path.

Reagents

A. 0.750 g alizarin red S dissolved in 1 liter distilled water.

B. 0.368 g $ZrOCl_2 \cdot 8H_2O$ or 0.294 g $ZrO(NO_3)_2 \cdot 2H_2O$ dissolved in 100 ml distilled water and 900 ml Scott's mixed acid added to make 1 liter.

Determination

Add 5 ml A followed by 5 ml B, accurately measured to 100 ml of sample or aliquot, the fluoride content of which is below 4.0 ppm. Mix after each addition. Read at 525 mμ after allowing to stand for 60 min at the standard temperature of the spectrophotometric curve.

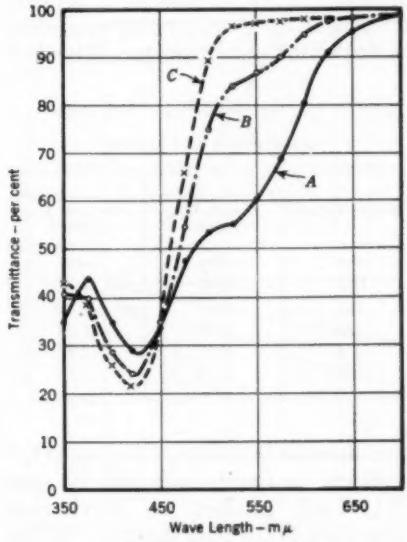

Fig. 3. Absorption Spectra for the Modified Fluoride Reagent

Curve A is for reagent plus 0.0 ppm fluoride; Curve B, for reagent plus 3.0 ppm fluoride; Curve C, for alizarin red S plus mixed acid. Light path was 1 cm.

In the construction of this curve, a series of fluoride standards between 0.00 and 4.00 ppm are prepared and allowed to react with the reagent for 60 min. The spectrophotometer is set to zero absorbency with distilled water in the absorption cell. Successive readings of the prepared standards are then taken and plotted. Because this color reaction varies with time, it is impracticable to set the zero point with a reagent blank (a standard containing 0.00 ppm fluoride) when a direct-reading spectrophotometer (similar to Beckman Model B or DU) is used. This restriction does not apply to instruments operating on the split-beam (null point) principle, provided the instrument is not subject to drift.

It is recommended that a new standard curve be constructed for each fresh batch of reagent prepared, as slight errors in weighing or in the purity of the chemicals used will produce a significant error in the results. Figures 3 and 4 give the absorption spectrum and a standard curve for the above reagent.

Interferences

The study of interferences was confined to ions normally present in natural water or added to drinking water during treatment. With the exception of aluminum, the ions did not in any test introduce a greater error than the present standard method and usually the interfering effects were greatly reduced. Figure 5 shows the extent of interference by the various ions. Calcium up to 400 ppm and magnesium up to 200 ppm have no effect. Sulfate and hexametaphosphate react similarly to fluoride, reducing the color—400 ppm SO_4^{-2} being equivalent to 0.1 ppm fluoride and 1.1 ppm $(NaPO_3)_6$ being equivalent to 0.1 ppm fluoride. Chloride, bicarbonate (alkalinity × 1.22), and ferric iron intensify the color produced by the reagent and thus produce

an effect opposite that of fluoride—1,800 ppm Cl^{-1}, 400 ppm HCO_3^{-1} and 5 ppm Fe^{+3} each reducing the fluoride reading by 0.1 ppm.

Chlorine interferes by exerting a bleaching action on alizarin red S. The extent of its interference depends on both the amount of chlorine and the amount of fluoride present; therefore, reduction of chlorine is necessary before the fluoride determination can be made. The effect of chlorine is shown in Table 1.

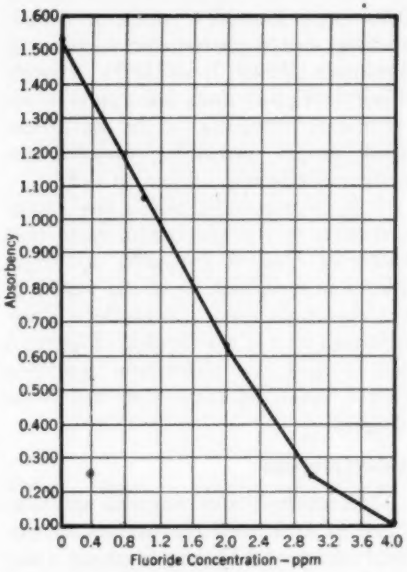

Fig. 4. Standard Curve for the Modified Fluoride Reagent

Light path was 7 cm; reaction time, 60 min; wave length, 525 mμ. Zirconium content was 0.5 mg in 100 ml water and ratio of alizarin to zirconium was 7.5 to 1 by weight.

Arsenite, sulfite and thiosulfate were used as dechlorinating agents. Sodium arsenite and sodium sulfite up to 200 ppm in excess did not interfere with the subsequent determination. Sodium thiosulfate in concentrations more than 100 ppm excess interferes because of its tendency to precipitate sulfur in acid solutions.

Phosphate also reacts similarly to fluoride. Its behavior, however, is unique in that when fluoride is absent, phosphate exerts a much greater effect on the reagent than when fluoride is present. When no fluoride is present, 1.5 ppm PO_4^{-3} gives a result equivalent to that of 0.1 ppm fluoride. When 1.0 ppm fluoride is present, 5.0 ppm PO_4^{-3} produces no interference, but 10 ppm PO_4^{-3} will produce an interference equivalent to 0.4 ppm fluoride. When 2.0 ppm fluoride is present, 10 ppm PO_4^{-3} produces no interference, but 20 ppm PO_4^{-3} will be equivalent to 0.32 ppm fluoride. The explanation of this phenomenon is not known. It is possible that the fluoride and phosphate ions, under the acidic condition of the test, combine to form a single anion, $(PO_3F)^{-2}$, which is also capable of decolorizing the zirconium-alizarin lake. A correction curve for phosphate is shown in Fig. 6.

TABLE 1

Interference by Chlorine

Chlorine Present	Apparent F when 0 ppm. F is present	Apparent F when 1.0 ppm. F is present
ppm.	*ppm.*	*ppm.*
0.5	0.00	1.06
1.0	0.07	1.10
2.0	0.20	1.27
3.0	0.36	1.42
5.0	0.78	1.70

Aluminum ion exerts an inhibitory effect on the fluoride reaction. It

forms a complex with fluoride ions $(AlF_6)^{-3}$ and prevents them from reacting with the zirconium-alizarin lake. Furthermore, the action of a given concentration of aluminum on the fluoride reaction is increased as the concentration of fluoride is increased. When there are no fluoride ions present, aluminum up to 5.0 ppm does not interfere. When the fluoride concentration is 1.0 ppm, 1.0 ppm aluminum

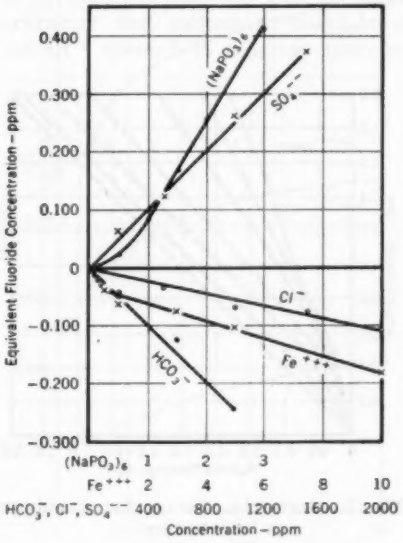

Fig. 5. Correction Curves for Ions Interfering With the Fluoride Determination

reduces the fluoride reading 0.39 ppm; 2.0 ppm. reduces it 0.57 ppm; and 3.0 ppm reduces it 0.63 ppm. When the fluoride concentration is 2.0 ppm, 1.0 ppm aluminum reduces it 0.47 ppm; 2.0 ppm reduces it 0.86 ppm; and 3.0 ppm reduces it 1.13 ppm. A correction curve for aluminum is shown in Fig. 7.

It is evident from the above data that phosphates, aluminum and chlorine can cause major errors in the fluoride determination if their presence or concentration is not known. Chlorine should cause no great concern to the analyst because it can easily be determined and eliminated. The presence of significant amounts of aluminum and phosphate in most public water supplies is rare. It should be required, however, that the analyst performing the fluoride test on an unknown water also make phosphate and aluminum determinations or a check determination by distillation before accepting as accurate the results of the spectrophotometric test.

Discussion

From the data presented, it is evident that the recommended reagent of itself need not be the one most practical for all laboratories. By holding the alizarin-zirconium ratio in the neighborhood of 7.5 to 1.0 by weight and varying the concentration of the reactants, it is possible to adjust the reagent to the fluoride range that is encountered most frequently in routine work. A change of 20 per cent in the zirconium-alizarin concentration in the reagent will move the absorbency reading of the spectrophotometer approximately 0.070 for each centimeter of light path available, but will have very little effect on the fluoride increment. Major changes in the alizarin-zirconium ratio will produce no practical benefits under the specified conditions of the reaction.

The effect of temperature on the standard curve was not studied, but it is obvious from previous work cited that the temperature of the unknown must approximate the temperature at which the standard curve was prepared. It would be advantageous for the an-

alyst performing a large number of fluoride determinations by the above method to prepare a series of standard curves depending on the temperatures prevailing in the water laboratory.

The effect of time is important; 60 min was chosen as a satisfactory time interval for accurate work. Although the color-producing reaction between zirconium and alizarin continues for an indefinite period of time, the change in the amount of color produced after 60 min is such that a 10-min error in reading will introduce an error of less

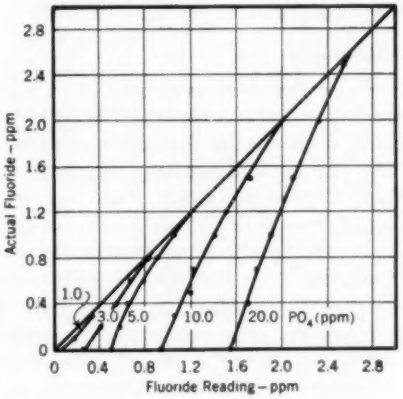

Fig. 6. Correction Curves for Phosphate Interference

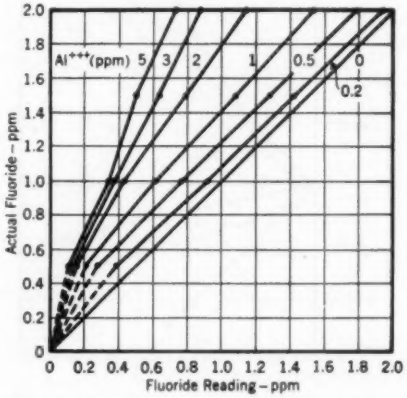

Fig. 7. Correction Curves for Aluminum Interference

than 0.05 ppm F. The error is much greater if a shorter reaction time interval is used, and decreases slowly as longer time intervals are applied. Thus, it is of no great advantage to prolong the reaction time, but a shorter reaction time will introduce greater errors in the individual readings. Figure 8 illustrates the effect of time on the amount of color produced by the reagent.

No effort was made to study in detail the concentration of acid which would be best for this reagent. The acid concentration given by the standard method was accepted as satisfactory. Major changes in acid concentration, such as doubling or halving the recommended amount, will produce significant variations in the color intensity developed by the reagent, and also in color increment per unit of fluoride. Acid concentrations in the magnitude of that recommended above seem to have the best combination of total color production and increment of color per unit of fluoride. Reduction of the acidity will increase color production but will retard the color increment per unit of fluoride, whereas increase of the acidity will retard both.

Visual Comparison

Many water laboratories that will be required to run routine fluoride determinations do not possess spectrophotometric equipment. Therefore, the above modified reagent was applied to visual comparison technique, using Nessler tubes. The recommended re-

agent is not completely satisfactory for visual comparison because the color in the low fluoride range is so intense that it becomes difficult to differentiate between fluoride increments 0.1 ppm apart in the range of 0.0 to 1.0 ppm fluoride. To overcome this difficulty the reagent was further modified so

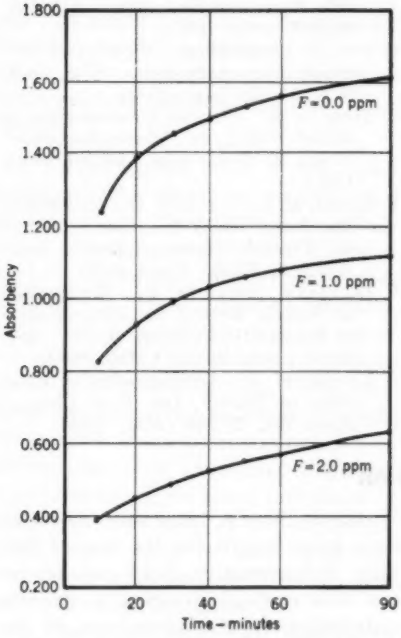

Fig. 8. Rate of Color Development With Recommended Spectrophotometric Reagent

Wave length was 525 mμ; temperature 23°C; light path 70 mm.

that it would be sensitive to small increments of fluoride when observed through Nessler tubes. Many combinations were tried. Evaluation of the several combinations was based on the ability of the eye to differentiate 0.02 ppm fluoride in the neighborhood of 1.0 ppm, and also on the ease of reading fluoride concentrations up to 2.0 ppm. The reagent recommended below fulfilled these conditions. It should be noted that this reagent can be prepared as a single reagent. It is unnecessary to separate the alizarin and zirconium because the aging effect of the reagent is nullified when a series of standards is prepared simultaneously with the unknown water sample.

Reagent Recommended for Visual Comparison Technique

1. Dissolve 0.420 g alizarin red S in 100 ml distilled water.
2. Dissolve 0.20 g $ZrO(NO_3)_2 \cdot 2H_2O$ or 0.251 g $ZrOCl_2 \cdot 8H_2O$ in 100 ml distilled water.
3. Add 58.6 ml concentrated H_2SO_4 to 500 ml distilled water.
4. Mix by pouring (1) into (2), add (3) and make up to 1 liter with distilled water. The reagent can be used after standing 1 hour.

Method

Add 5 ml accurately measured of the reagent to 100-ml samples and a series of standards; mix. Allow to stand approximately 1 hour before making comparison.

The above reagent is prepared with the acid recommended by Lamar (10). It was found that it is easier by eye to distinguish slight changes in color with this acid than with the one recommended by the standard method because the background of yellow color seems less intense when H_2SO_4 alone is used.

Interference by other ions is practically the same with this reagent as with the one recommended for spectrophotometric measurement, for the alizarin-zirconium ratio is but slightly changed. Phosphate has even less effect, 10 ppm being necessary to produce an apparent fluoride residual of 0.1

ppm when no fluoride is present. There is no interference at 20 ppm phosphate when 1.0 ppm is present.

Summary

A modified zirconium-alizarin reagent is proposed for use in the spectrophotometric determination of fluoride in water. This reagent is sensitive to small increments of fluoride over a range of 0.0 to 3.0 ppm and it approximates Beer's law over this range. The effect of interfering ions is evaluated.

By further modification, the reagent is adjusted for visual comparison techniques so that it is effective over a range of 0.0 to 2.0 ppm fluoride and sensitive to 0.02-ppm increments of fluoride.

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Discussion

Standard Methods Subcommittee on Fluorides

Subcommittee S–14 on Fluorides of AWWA Committee E5–9, Standard Methods for the Examination of Water & Sewage. The subcommittee personnel who prepared this discussion include: Charles A. Black, Chairman; W. L. Lamar; and Michael Taras.

The modified zirconium-alizarin reagent for the determination of fluoride in water introduced here presents certain fundamentals for the adaptation of the zirconium-alizarin procedure to photometric methods. As a result of its review of the work of Megregian and Maier on the selection of the proper zirconium-alizarin ratio and the optimum wave length for the use of this ratio, Subcommittee S–14 can report that this method presents a definite contribution in the adaptation of the fluoride determination to photometric procedures.

The method proposed for photometric work seems to follow Beer's law in concentrations up to 3 ppm, as this is the recommended limit set by the authors for the particular ratio of zirconium to alizarin used. A paper published by Johanna P. Boonstra on a modification of the Sanchis method (see reference 9, above) also provides a photometric procedure that was studied by this committee and found to be

inferior to the Megregian and Maier modification on several significant counts. The 4-hr reaction time of the Boonstra method is a major drawback as is the extra operation of heating the sample. Also, the committee failed to obtain reproducible results consistently with this modification.

In reviewing the article by Megregian and Maier, the different committee members made a number of points which, it was felt, should be presented as suggestions and notations in this discussion:

1. Of particular value in this presentation is the report of the successful use of sodium thiosulfate, sodium sulfite, and sodium arsenite for eliminating the common interferences contributed by free chlorine residuals. Controversy has arisen in some quarters about the applicability of sodium thiosulfate for this purpose. This misunderstanding about sodium thiosulfate presumably stems from the practice of adding macro, or excessive, quantities to remove micro, or trace, quantities of chlorine. The body of knowledge on these matters must be built up by experimental evidence such as is presented here by the authors.

2. The color filter and the initial light intensity are important considerations in the use of a filter photometer for the fluoride determination. If a long cell path, such as 5 cm, is employed, the relatively deep color of the reagent blank coupled with the light intensity will limit the effective transmission spread. Committee member Taras has experience with two types of color filters which illustrate this point. Fortunately, either of these filter types can be inserted in the same instrument. The regular green filter supplied with the instrument is quite thick, making it necessary to null the reagent blank at 20 per cent transmittance. The thinner Wratten green filter, on the other hand, passes more light, thereby permitting a null at 50 per cent transmittance and affording a transmittance reading up to 87 per cent between 0.0 and 1.5 ppm fluoride. The transmittance spread with the thicker filter is between 20 and 48 per cent for the same fluoride range. The thickness of the filter and not the wave length is responsible for this phenomena. In the case of the Beckman Model DU spectrophotometer, it is possible to use the extended range of 10 to 80 per cent transmittance for a concentration of 0.0 to 1.5 ppm merely by enlarging the slit width to about 1.5 mm, admitting more light, instead of the customary method of operating with minimum slits.

3. It should be emphasized that, if a photometric determination is made with this method, the actual determination of the unknown sample must always be performed at the same temperature at which the calibration curve was made. It is suggested that several curves be prepared at different temperatures if the laboratory does not have a satisfactory way of controlling the temperature of the sample.

4. The committee was not able to verify the precision on the order of 0.02 ppm fluoride. It is, of course, frequently difficult to specify exactly the order of precision and accuracy because of the factors of concentration and interferences. In the determinations tried with distilled water containing small amounts of fluoride, deviations greater than the 0.02 ppm fluoride reported by the authors were noted. Deviations occurring in actual water samples should be even greater because of interfering ions and color.

5. Studies made by members of this committee bear out the authors' opinion concerning the advantage of the use of sulfuric acid alone for the visual procedure instead of the mixed acids used in the photometric procedure.

6. The visual comparison procedure presented is convenient and satisfactory within the limitations of the zirconium-alizarin method, but it does not offer anything new. What is offered is a concentration which does promote darker shades of color but the sensitivity or range is not increased. The authors imply an improvement in the sensitivity of the visual procedure, but it is not apparent.

Conclusion

The work of Megregian and Maier presents a fundamental contribution to the problem of determining fluorides in water. The committee feels that it is not the final answer but it is a definite step in the right direction. For the present and immediate future, the committee finds the Megregian-Maier modification the best on the scientific horizon for photometric purposes. Although far from ideal, it answers an imperative need. It is not felt, however, that the visual comparison procedure as proposed presents any new and distinct advantages over the present Scott-Sanchis modification which would warrant the latter's discontinuance in favor of the Megregian and Maier modification. The photometric procedure presents, for those interested, a method which generally will give good results if the proper care and precautions are exercised.

Notes on Distribution System Maintenance

By D. H. Goldsborough

A paper presented on November 1, 1951, at the Chesapeake Section Meeting, Baltimore, Md., by D. H. Goldsborough, Sr. Assoc. Engr., Bureau of Water Supply, Baltimore, Md.

AS the distribution system represents a very large proportion of the investment of any water supply system, its proper maintenance is of first importance. Realizing this, the Baltimore Bureau of Water Supply has been careful to develop a well-trained maintenance staff and to equip it with the proper tools. Some notes regarding the practices of the Bureau may therefore be helpful in suggesting solutions to problems faced in other water systems.

Valves

The importance of proper operation, accessibility, and complete records of valves in a distribution system cannot be overemphasized. In older systems where there are valves of different manufacture, the make, number of turns, and direction of rotation of every valve should be recorded in such a way that the information is readily available. This is particularly important for valves 20 in. in diameter and larger on transmission mains.

It is good policy to restrict operation of valves 12 in. and larger to a special valve-operating crew, well trained and well versed in valve construction and repair. Such a crew always proves invaluable under emergency conditions, when breaks on large transmission mains call for speed and special knowledge to effect a quick shut-down. Foremen of such crews should be instructed to keep an accurate count of the number of turns during closure on each valve operated—a simple matter when a mechanical valve-operating device equipped with an automatic counter is used.

The Bureau has two completely equipped emergency valve-operating trucks, one of which is on 24-hr service and the other in reserve (Fig. 1). The trucks are alternated every two weeks. These units are equipped with a mechanical valve-operating device, a 750-gpm centrifugal pump, a small portable gasoline-operated pump, and a complete set of tools. A two-way radio is provided on both units. The crew consists of a foreman, chauffeur and two helpers.*

In a system of any size with many valves on transmission mains, it is imperative that at least one crew devote its entire time to a systematic check and inspection of valves. If a defect is uncovered, the same crew, equipped with the proper tools, should immediately make the necessary repairs. The checkup should include operation of the valve to full closure and taking

* An informal review of the availability of this type of equipment in six large utilities known for their good administrative practices revealed that an average of one fully equipped mobile unit was provided per 100 miles of mains.—Ed.

note of the number of turns, if this is possible.

In geared valves, the adoption of the enclosed gear case on all new installations will provide a decided advantage. If possible, a program should be initiated to convert all existing geared valves in a system to this style. Such a practice can reduce repairs on the larger valves to the barest minimum.

Much has been said and written about distribution system main and valve records. Some authorities maintain elaborate card systems, including intersection sketches, and many types of field records have been proposed. In Baltimore the most satisfactory type of shut-off field sheet found is a form of strip map used for transmission main operations. These sheets may be indexed and bound in a stout binder or indexed and filed in a case so that the sheets may be used individually. They give measurements of all valves, their size, location of mains, and other pertinent data, and are so arranged that any transmission main can be shut down by consulting only one or two of them. These same sheets may be used by the valve inspection and repair crew in their survey. But whatever type of record, it is, of course, essential for the operating engineer to see that it is kept up to the minute, and to correct any discrepancy immediately.

In any distribution system divided into various zones of service, it is an excellent idea to have a complete record handy for field use so that a prompt, systematic check can be made when there is evidence that a division valve has been opened. These record sheets should be arranged so that each sheet contains the complete record of boundary valves for each zone. Division valves should be properly marked with a distinguishing cover or some form of notice or lock on the operating nut so that they will not be inadvertently operated. It is the practice of the

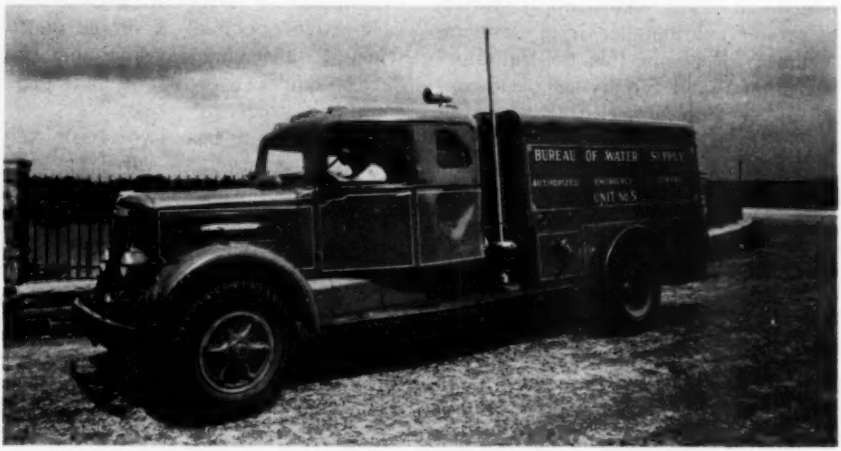


Fig. 1. Baltimore Bureau of Water Supply Emergency Truck

Equipment includes a mechanical valve-operating device, a 750-gpm centrifugal pump, and a smaller gasoline-operated one. A two-way radio set is also included.

Bureau to use vaults of brick or concrete with concrete slabs and access manholes to house valves of 16-in. and larger completely. For the smaller size valves, cast-iron roadway boxes or sectional precast concrete vaults are used. The sectional vaults are constructed in two sizes and are poured in the Bureau's own shop or purchased from local manufacturers who construct them to its specifications. The tendency is toward the elimination of the roadway box, and valves that have to be excavated for repair are provided with the sectional vault wherever possible. Such vaults are of sufficient size to permit repairs without disturbing the paving. One feature of interest in the sectional vaults is that the precast slab is doubly reinforced so that failure by accidental reversal in installation is impossible. These same vaults can be used to house compound meters, the large ones accommodating sizes up to 6-in.

Pipe Repair Clamps

The use of repair clamps and bell joint clamps in distribution system repairs becomes increasingly important with increased labor costs and material shortages.

Many failures in cast-iron mains in sizes 8 in. and smaller are of the circumferential type—that is, the failure is at right angles to the pipe axis. Such a break is quickly and satisfactorily repaired with a pipe repair clamp. The repair is permanent and the clamp adds a flexibility to the main that was lacking in the original installation. The type of failure noted above almost always occurs where the main is not supported uniformly throughout its length. A typical example is where the main is installed throughout part of its length directly on an unyielding concrete duct line or flat top sewer.

The type of clamp designed to repair fractures parallel to the pipe axis may not be so successful, as the crack may continue beyond the clamp some time after its installation.

Bell-joint clamps should be seriously considered as a means of preventive maintenance where a main is installed with greater or less cover than normal or in such inaccessible locations as railroad crossings. In preparing plans for a new main installation, the engineer

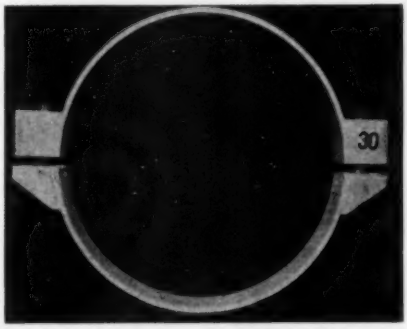


Fig. 2. Friction Clamp for Repair of Odd-Size Pipe

Clamp is used primarily to prevent outward movement of recalked lead joints.

should pay special attention to locations where the use of such clamps may save the expenditure of much time and money in the future. In routine maintenance, good practice dictates that they be installed on any joint that indicates the possibility of giving trouble in the future. Many joints originally poured with a jointing material other than lead have been repaired by chipping out an inch or so of the jointing material, repouring with lead, and installing a bell-joint clamp.

Difficulties present themselves from time to time where the ordinary bell-joint clamp will not fit an old main or

oversize pipe. For this problem, the Bureau has developed what is called a friction clamp (Fig. 2), which can be fabricated quickly and does an excellent job in preventing the lead joint from moving out again after recalking. The pipe is accurately calipered and a split clamp is made of flat steel stock about 3 in. wide, the thickness depending on the size of the joint. The bolting ears are reinforced with welded haunches for stiffening, and two suitably sized draw bolts are provided. The two halves of the clamp are lightly bolted and then forced against the face of the joint. The bolts are then given a final tightening, and the friction of the clamp thereby prevents future outward movement of the joint.

The renewal of services or house connections between the main and the curb sometimes presents a problem in connecting to the customer's side of the service pipe. These lines are often old and so deteriorated that it is impossible to cut a thread. Leaving the consumer without water and instructing him to employ a plumber can often cause quite a strain on public relations. The Bureau now carries an ample stock of compression couplings which enables it to make connections that might otherwise be impossible.

Hoist Truck

An important piece of Baltimore's distribution system maintenance equipment is a home-made hoist truck (Fig. 3). The Bureau started with a 1½-ton truck which was about to be retired from active service because of age, although mechanically it was still in good condition. With the exception of the cab, the truck was stripped to the chassis and steel reinforcement added to support a checkered steel floor plate. An A-frame and trolley beam were welded in place to support the 1-ton chain fall. This chain fall is provided with a steel housing just behind the cab to protect it from the weather. Movable stops were installed on either side of the chain-fall trolley in order to hold the fall at any point throughout the

Fig. 3. Home-Made Hoist Truck

Built on a 1½-ton truck about to be retired, the 1-ton hoist can pick up an 8-in. meter weighing 1,800 lb. and suspend it at the extreme end of the beam as shown.

length of the beam. The beam projects four feet beyond the deck. Steel boxes were added on both running boards for the storage of slings and tools.

This truck is particularly useful in handling large meters. An 8-in. meter weighing 1,800 lb. can be suspended at the extreme end of the beam. The truck can deliver the meter to the job and then set the meter with the minimum effort. Another use is in the replacement and setting of fire hydrants and dismantling and reassembling large valves in the field.

Radio

Much has been written in the JOURNAL and elsewhere about radio as an aid to water works operations. The author has no intention to elaborate here on the various types of equipment and the technical details, but any water distribution system operator, who once uses radio, will wonder how he formerly managed to handle his manifold problems without it.

Of particular advantage is the system which uses frequency modulation, with the base transmitter and the mobile transmitters and receivers operating on the same frequency. Known as the single-frequency system, this method will permit mobile units to communicate directly with each other where tests are being conducted or valves operated, and where the intervening distance is too great for visual signaling and transportation between the locations is too time-consuming for efficiency. The time saved in reducing water damage and the generally increased efficiency will more than offset the cost of the radio installation.

Safety

Safety in water works maintenance is primarily a problem of making a few essential rules and regulations, and then having the supervisory force see that they are rigidly followed. Certain "must" regulations have been established by the Bureau. For example: a man operating a pneumatic paving breaker must wear foot guards; when air-calking is done, or hand- or air-operated pipe cutters are used, the workmen must wear goggles. Stress is put on the use and proper placement of warning signs while work in the street bed is in progress; also sufficient and well-placed warning lights must be used at night. Flagmen are assigned to work in heavily traveled streets or at dangerous intersections, where such practice is indicated. These are actually the only written rules.

The shoring of ditches is left to the discretion of the engineers, and these men have been impressed with the gravity of their responsibility. Good housekeeping on the job and the use of the proper tool for each job are important considerations. The men are encouraged to make suggestions, and this policy has led to the development of several useful tools for specific jobs.

The key to a successful safety program is eternal vigilance.

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1951

A report of the activities of the Committee on Water Works Practice for the year ending December 31, 1951, submitted to the AWWA Board of Directors on Jan. 14, 1952, by Louis R. Howson, Chairman.

FOLLOWING is a report of the technical committee activities of the Association conducted under the guidance of the Committee on Water Works Practice during the calendar year 1951:

E6A—Water Hammer. A complete session at the Kansas City Conference will be devoted to design requirements for water pipe as affected by water hammer. S. L. Kerr, who will be the moderator of this session, has been appointed chairman of a reactivated Committee on Water Hammer and will select the personnel of the committee, subject to routine approval requirements.

E7A—Steel Pipe. Chairman Hurlbut's report states:

1. Specifications C201–50 and C202–49 (formerly 7A.3 and 7A.4) for fusion welded steel pipe of sizes 30 in. and larger and up to 30 in., respectively, are now being studied by Committee E7A with a view to combining the two specifications into a single document covering all sizes.

2. Specifications C203–51 and C204–51 (formerly 7A.5 and 7A.6) for coal-tar enamel protective coatings for steel pipe of sizes 30 in. and larger and up to 30 in., respectively, have been revised to modernize their references to ASTM specifications for certain testing procedures. Committee E7A is investigating the possibility of combining both these specifications into a single document covering all pipe sizes. In addition it is investigating vendors' responsibility in the shipping of pipe coated in accordance with the specifications.

3. Since the Board action of January 1951, withdrawing Sec. 4 of Specifications C205–41 (formerly 7A.7) for cement-mortar protective coating of large steel pipe and instructing Committee E7A to submit new specifications for the application of cement-mortar lining applied in place to steel pipe, the committee has been investigating means of producing specifications which would specify results rather than methods. Committee E7A has approved, in principle, the promulgation of two separate documents, one document covering shop-applied spun-cement-mortar lining and protective coatings, and another document covering cement-mortar lining applied to steel pipe in place. The committee has been investigating the thicknesses and tolerances of cement-mortar lining for the various sizes of pipes, together with alternate means of reinforcement of the exterior mortar coating.

E7B—Reinforced Concrete Pipe. Tentative specifications for nonclyinder, nonprestressed reinforced pipe, developed by the committee, were approved by the Board and published in the October 1951 JOURNAL. The Association now has three documents in this series: C300–47T (formerly 7B.1–

T), Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed; C301–49T (formerly 7B.2–T), Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed; C302–51T, Tentative Standard Specifications for Reinforced Concrete Water Pipe—Noncylinder, Not Prestressed. Chairman Whitlock has advised that the two earlier documents will now be revised editorially in order to make the sections covering the same details parallel in phraseology.

It is proposed to complete the development of the manual on installation of reinforced concrete pipe during 1952.

A21—Specifications for Cast-Iron Pipe and Special Castings. The development of specifications for cast-iron pipe is in the hands of ASA Committee A21, which operates under the Chairmanship of T. H. Wiggin. AWWA is sponsor of this project along with NEWWA, AGA, and ASTM. (Attached to this report as Appendix B–1 is a digest of the current activities of this committee.) As of January 3, 1952, by direction of Chairman Wiggin, the AWWA Secretary requested NEWWA, AGA, and ASTM to accept a modified text of Sec. 10–13 (A21.10) referring to lining or coating of pipe produced for water works use. This section has been the subject of discussion at several Board meetings, since the Committee on Water Works Practice, as well as the Board, found itself unable to accept the document with no positive requirement covering lining or coating of cast-iron water pipe and fittings. The omission has now been corrected by Committee A21. The revised section will read:

> Any particular lining or coating which is to be applied to the fittings shall be specified in the agreement made at the time of purchase. Separate specifications for cement-mortar lining have been provided in connection with these specifications for fittings (*see* ASA A21.4).
>
> No fittings for water works service shall be furnished without protective coating unless specifically ordered by the purchaser.

E7D—Installation of Cast-Iron Pipe. No formal request for revision of any portion of this tentative standard, C-600–49T (formerly 7D.1–T), published in the December 1949 JOURNAL, has been filed. It is still necessary to hold in abeyance the advancement of the document to standard status, however, as instructions for installation of mechanical-joint pipe cannot be included until the specifications for mechanical joints have been approved. There also remains the problem of using jute as a jointing material for bell-and-spigot pipe. Jute was omitted from the list of materials recommended in the 1949 document. Discussions with jute processors since that time led to the agreement that they would develop and file with the Bureau of Standards a commercial standard for treated jute. After a year's delay, such a proposed standard was filed with the Bureau of Standards and has been reviewed by the Secretary. Exceptions to it have been filed with the Bureau. As yet, no hearing has been held. Unless the commercial standard is acceptable to AWWA, jute—treated or untreated—will not be listed as an acceptable pipe-joining material.

E7D–2—Disinfection of Water Mains. The committee has in process changes in specifications C601–48 (formerly 7D.2) for disinfecting water mains, which are intended to make optional certain procedures that are specifically required by the present text. These requirements, relating to such

items as swabbing of pipe have been objected to by executives whose experience indicates that later flushing of the completed line and disinfection with chlorine produces satisfactory results. The references in the current document to the use of jute will also be modified to make them consistent with the specifications for installation of cast-iron mains.

E7E—Asbestos-Cement Pipe. As of October 12, 1951, revised text of specifications for asbestos-cement pipe was transmitted by Chairman Clarke to the Committee on Water Works Practice. Three preliminary drafts of the specifications have been sent to the committee membership and comments thereon received from all members. The draft as finally submitted attempts, as nearly as possible, to meet all objections. There remain three major items on which members of the committee disagree:

1. Mr. Cook desires that the outside diameter of all pipe up to 12 in. be such as to permit its use with standard cast-iron bells. The specifications as written permit, but do not require, this adaptability. Such design is standard with both manufacturers for sizes through 8 in. in Classes 100 and 150. Keasbey & Mattison, which makes only sizes through 12 in. and only Classes 100 and 150, manufactures all pipe to fit cast-iron bells.

In view of the above facts and of the fact that adapters are available for all Johns-Manville pipe, the majority of the committee feels that the proposed requirement is not justified.

2. Keasbey & Mattison desires to reduce the hydrostatic test pressure from $3\frac{1}{2}$ times to $3\frac{1}{3}$ times the indicated working pressures. The large majority of the committee agrees that the higher pressures should be kept.

3. Mr. MacDonald disapproves of the proposed specifications on the basis that the product will not be comparable in strength to cast-iron pipe. Mr. Cunningham indicates the desirability of making the asbestos-cement pipe equivalent to cast-iron pipe but subscribes to the specifications as written, because he feels "that they are a great improvement over the federal specifications and probably a reasonable compromise."

This last statement probably reflects the thinking of a majority of the committee. The only alternative is to specify pipe-wall thicknesses or a method of computing the thickness from unit strengths of the asbestos-cement material. Specified wall thicknesses would have no meaning unless related to a unit strength. Tests to determine such unit strengths do not appear to be feasible.

Following receipt of the text, Mr. Howson and Mr. Veatch have filed disapproval statements, and Mr. Howson has requested that the document be reviewed by the Committee on Water Works Practice and the working committee at Kansas City.

E7F–1 and E7F–3—Valves and Fire *Hydrants.* During 1951 staff time has been devoted to discussion of the pending revisions of specifications C500–39 (formerly 7F.1) for gate valves and specifications C502–40 (formerly 7F.3) for fire hydrants, with representatives of manufacturers and with consumer members of the two committees. A draft of the valve specifications, satisfactory to most of the manufacturers, was reviewed on December 20, 1951, with a group of consumer members of the committee. Many elements in the text as submitted are completely unacceptable to the consumers and further revisions are now in progress. A draft of the hydrant specifications, in the

main acceptable to the manufacturers, was reviewed on December 20, 1951, with the same consumer group and found not acceptable in the same details as were objected to in the valve specifications. The principal issues lie in the application of certain physical and chemical requirements to components of the valves and hydrants as well as to the form of statement on test bars. It is planned to submit to the Committee on Water Works Practice by February 15, 1952, a revised text of each document which in the judgment of the Secretary will be fair to both the producer and the consumer, and submit it to the Board as soon thereafter as committee returns will permit.

E7M—Meters. Following a conference of NPA officials with representatives of the meter industry, a conference was held by certain meter producers with Meter Adviser Newkirk and Secretary Jordan. The suggestions made by NPA relating to substitution of certain ferrous metal parts for copper or bronze parts were reviewed. Mr. Newkirk has submitted a recommendation for emergency amendment of the specifications (Appendix C). The Association is prepared, by the steps outlined in its standardization procedure, to adopt such recommendations promptly.

E7S—Service-Line Materials. This committee has collected, from a large number of cities, data concerning service-line-installation practices and is presently engaged in analyzing and summarizing the information. It will be published when complete.

Joint Committees With Other Organizations

Field Welding of Water Pipe Joints. This committee, organized in 1942, has prepared one document which is now standard. The committee is inactive but stands on the records of AWS and AWWA as organized and ready for action if needed.

Steel Standpipes and Elevated Tanks. This committee under the chairmanship of H. O. Hill has for several months been actively at work on a revision of the texts covering materials and erection as well as painting. The discussions are nearing a close, and submittal of revised documents is anticipated before the Kansas City Conference.

Dimensions of Flanges for Steel Water Pipe. This committee, composed of members representing AWWA and ASME, has been active during 1951 and has reached the end of its deliberations. By letter dated January 7, 1952, the chairman of the joint committee advised that the proposed standard had been approved by the special committee. The material will now be submitted to the AWWA Steel Pipe Committee. If approved by that group as well as by the Committee on Water Works Practice, the Officers and Directors will be asked to decide whether to promulgate the document as an AWWA standard or submit it to ASA as a joint document of AWWA and ASME.

Correlating Committee on Cathodic Protection. The work that this committee set out to accomplish has been completed and published. The committee wishes to liquidate. The AWWA members should be thanked and discharged.

Deep Well Vertical Pumps. A second report of this committee is now in preparation. There is good evidence that the project can be completed in 1952.

ASA Committees B26 and B33. Efforts have been made to consolidate the Committees on Hose Coupling Threads

and Fire-Hose Coupling Threads. For a number of years, separate committees have been engaged in these developments, and it has appeared to some that, under present conditions, one committee can handle the revision of the two sets of existing specifications. The discussions are not complete. George Tatnall of Chicago is AWWA representative in this activity.

In the Dominion of Canada, civilian defense activities with the Canadian Standards Assn. led to the appointment of Mr. MacDonald of Ottawa to represent the water works industry in this work. He has recently filed a highly competent report which discloses the fact that uniform standardization of fire-hose couplings within the Dominion will be quite difficult. He is to be commended highly for his diligent attention to this important matter of public policy. Existing practices within the various provinces vary, generally, among couplings having 5, 7, or 8 threads per in.—compared with the U.S. standard of 7½ threads per in. It is of interest to note that, of the states bordering Canada, all uniformly conform with the U.S. standard 7½ threads, except New York, Michigan, and Vermont. It is striking to note that cities in New York State having 90 per cent of the state's urban population do not comply with the U.S. standard fire-hose thread.

Committees Operating Under the Water Purification Division

Specifications for Filtering Materials. Comments have been made by a purchaser of filter gravel which indicate the propriety of adding to the existing specifications a brief statement to the effect that neither gravel nor sand, otherwise conforming to the specifications, shall be acceptable if it contains water-soluble material (iron, manganese, and other chemicals) which will degrade the filtered water. It is to be understood, however, that ion-exchange materials may easily produce a filtered product which requires that the supporting gravel be of quality and characteristics specially designated by the purchaser and intended to avoid adverse results with the exchange material being used.

Open-Air Reservoirs (for finished water). This committee which has been engaged in its activities for some time, and which has found it difficult to reconcile theoretical safety requirements with actual conditions of open reservoirs, proposes to present a final report at the Kansas City Conference.

Specifications for Water Treatment Chemicals. This project is spearheaded by James E. Kerslake with diligence and competence. The following standards were published during 1951: [1] B600–49T (formerly 5W1.70–T) for powdered activated carbon (February JOURNAL); and [2] B501–51T for caustic soda (December JOURNAL).

Specifications for soda ash are completed, and were published in the February 1952 JOURNAL.

The following documents are essentially complete, and the referees' considerations of comments now in hand will permit their publication during 1952: [1] aluminum sulfate; and [2] lime (quicklime and hydrated).

The following specifications are now in the draft stage and await acceptance by the division officers: [1] sodium silocofluoride; and [2] copper sulfate.

Mr. Kerslake expects to prepare and submit drafts of the following specifications during 1952: [1] ferric sulfate; and [2] hypochlorites.

The following documents were prepared by the committee and published prior to 1951:

Designation		Title	Published in Journal
Present	Former		
B200–49T	5W1.01–T	Tentative Standard Specifications for Sodium Chloride	Mar. 1950, p. 317
B400–49T	5W1.10–T	Tentative Standard Specifications for Ammonium Sulfate	Nov. 1950, p. 1087
B401–50T	5W1.30–T	Tentative Standard Specifications for Bauxite	July 1950, p. 707
B402–49T	5W1.31–T	Tentative Standard Specifications for Ferrous Sulfate	Oct. 1950, p. 975
B500–50T	5W1.60–T	Tentative Standard Specifications for Trisodium Phosphate	June 1950, p. 601
B701–50T	5W1.90–T	Tentative Standard Specifications for Sodium Fluoride	Sept. 1950, p. 897

Disposal of Purification Plant Wastes. The committee has not yet developed recommendations for disposal of wastes of routine water treatment. It has completed recommendations for disposal of wastes of lime and zeolite softening plants.

Fluoridation Materials and Methods. This phase of water treatment is extremely active. Several papers upon the subjects assigned to the committee were published in the JOURNAL during 1951. In cooperation with a committee of the Conference of State Sanitary Engineers, information is being summarized on the extent of fluoridation of public water supplies at the end of 1951.

Instrumentation and Methods for Testing for Radioactive Contamination of Water. This committee is diligently at work and proposes to present a progress report at the Kansas City Conference. Although the volume of literature related to decontamination of water grew rapidly during 1951, the water works industry needs information concerning detection of radioactive contamination.

Standard Methods for the Examination of Water and Sewage. The tenth edition of this important text is nearing committee completion and will be placed in the hands of the printer sometime in 1952. The Federation of Sewage and Industrial Wastes Assns. will join AWWA and APHA in sponsoring the tenth edition. The AWWA subcommittee under direction of R. L. Derby is charged with the preparation of chemical methods of water examination.

A special task group under Mr. Derby's leadership is also engaged in study of the membrane filter technique of bacteriological examination of water. In the December 1951 JOURNAL, an important series of records of membrane filter results were published. General coordination of all bacteriological examination methods rests with the APHA representatives on the Joint Editorial Board.

Special Task Groups. The division has established three special task groups to prepare revision material for the following chapters in the *Manual of Water Quality and Treatment:* Mixing, Flocculation and Sedimentation, Chairman H. E. Lordley; Aeration, Chairman Guy R. Scott; and Filtration, Chairman R. L. McNamee. The third task group is also charged with an appraisal of the values and limitations of high-rate filtration.

Review Topics. The subject "Corrosion-Inhibiting Methods" is assigned to Rolf Eliassen for review, and "Bio-

logical and Chemical Problems of Water Distribution Systems" to D. W. Graham. No committee is organized under either chairman, but each is charged with the duty of presenting to the division a digest of research and reports upon the subject noted during the previous year.

Committees and Task Groups Under the Water Resources Division

Deep Wells

This committee has, during 1951, been engaged in the development of recommended procedure for sealing abandoned wells. A preliminary draft of the report was discussed during the Miami Conference. Since that time, the material has been revised and is now being circulated within the committee for approval. In due time it will be presented to the Board.

Public Use of Reservoir Areas (Task Group). Chairman L. S. Finch proposes to reactivate this project and prepare a formal report for the 1953 convention.

Watershed Protection and Erosion Control (Task Group). Burton S. Grant has accepted the chairmanship of this redesignated activity and proposes a formal report at the 1953 convention.

Industrial Water Use (Task Group). Chairman Hudson proposes a brief summary of studies in 1952. It is proposed to develop a series of definitions of terms used in water-use studies, as much confusion is developing because of variations in the understanding of terms currently used.

New Task Groups

The Water Resources Division has, during 1951, organized several new Task Groups.

Weather Control. The functions of this task group are to: [1] study and report upon any significant events and trends in the field of man-made control and influence of natural weather conditions insofar as these factors may influence the pattern of availability of water for water works; and [2] identify and recommend subjects and possible speakers for the general conference programs.

Production of Usable Water From Salt Water. The functions of this task group are to: [1] study and report upon any significant events and trends in the field of production of usable water from salt water insofar as these factors are of interest to the water works industry; and [2] identify and recommend subjects and possible speakers for the general conference programs.

Artificial Ground Water Recharge. The functions of this task group are to: [1] study and report upon any significant events and trends in the field of artificial recharging of underground aquifers insofar as these factors affect current or future sources of supply for water works; and [2] identify and recommend subjects and possible speakers for the general conference programs.

Underground Water Disposal and Control. The functions of this task group are to: [1] study and report upon any significant events and trends in the field of waste disposal into the ground insofar as these factors affect current or future sources of water supply for the public and industry; [2] formulate recommendations covering protection of fresh ground waters from hazardous or objectionable pollution through waste disposal into the ground; and [3] identify and recommend subjects and possible speakers for the general conference programs. Disposal of

brine wastes into brine aquifers and salt water intrusion from the sea are to be excluded from the assignment for the present.

These task groups were established during 1951 and only preliminary reports may be expected at the Kansas City Conference.

APPENDIX A—Personnel Changes and New Appointments

E5-10—Fluoridation Materials and Methods. J. C. Zufelt resigned as chairman but remained as member of committee, O. J. Muegge was appointed chairman, and Charles R. Cox was added to committee.

ASA Committees

A13—Scheme for Identification of Piping Systems. R. J. Faust was appointed AWWA liaison representative.

B33—Screw Threads for Hose Couplings. George Tatnall was appointed AWWA representative.

K61—Storage and Handling of Anhydrous Ammonia and Ammonia Solutions. R. J. Faust was appointed AWWA representative.

Z48—Marking Compressed Gas Cylinders. R. J. Faust was appointed AWWA representative.

ASME Committee on Abbreviations (AWWA No. R4). E. F. Johnson was appointed AWWA representative.

AGA Technical Advisory Group for Domestic Gas Water-Heating Research (AWWA No. R17). A. A. Ulrich was appointed AWWA representative.

APPENDIX B—ASA A21 Specifications

As of January 4, 1952, the following progress is reported:

A21.1-1939—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe. Work on revision of the manual has been delayed while awaiting data from Prof. Schlick, Iowa State College. Chairman Wiggin advised on Jan. 4, 1952, that he does not wish to recommend reprinting of the manual without the data on the effect of a superload on pipe in a trench. He will keep pressing for the data.

A21.2-1939—American Standard Specifications for Cast-Iron Pit-Cast Pipe for Water or Other Liquids. Bituminous coating clauses have been altered as agreed. Sulfur specifications still remain at 0.10 per cent. Chairman Wiggin wrote metallurgists on Jan. 2, 1952, asking for their views on changing sulfur content to 0.12 per cent. This change was requested by the producers and has previously been approved for centrifugally cast pipe. There is also some question concerning the retention of the hammer test in the hydrostatic test.

A21.3—Pit-Cast Pipe for Gas. Sectional Committee approval ballots were on Dec. 28, 1951, being received by the Chairman. Sulfur content change from 0.10 per cent to 0.12 per cent is now being considered.

A21.4-1939—American Standard Specifications for Cement-Mortar Lining for Cast-Iron Pipe and Fittings. On Jan. 9, 1952, Technical Committee 3, by letter ballot, approved the specifications. Letter ballots are now being prepared for submission to the Sectional Committee.

A21.5—Tar-Dip Coating. AWWA, as a sponsor, declined to accept this document. On Feb. 25, 1948, Committee A21 officially withdrew A21.5.

A21.6—Pipe Centrifugally Cast in Metal Molds, for Water. Ballot now ready for submission to A21 Sectional Committee for approval on lining and coating change as requested by AWWA in May 1951. Ballot sent Jan. 11, 1952.

A21.7—Pipe Centrifugally Cast in Metal Molds, for Gas. Same status as A21.3, except for sulfur which had previously been changed to 0.12 per cent.

A21.8—Pipe Centrifugally Cast in Sand-Lined Molds, for Water. Same status as A21.6.

A21.9—Pipe Centrifugally Cast in Sand-Lined Molds, for Gas. Same status as A21.3 except for sulfur.

A21.10—Short Body Cast-Iron Fittings, 3-Inch to 12-Inch, for 250-psi. Water Pressure Plus Water Hammer. Chairman Wiggin requested AWWA on Dec. 31, 1951, to obtain sponsor approval for these specifications. The new coating clause has the approval of A21 Committee. It will be recalled that these specifications were previously approved by sponsors as follows: AWWA, Feb. 17, 1950; NEWWA, Feb. 16, 1950; AGA, Apr. 10, 1950; and ASTM, May 9, 1950. The change in the coating and lining clause as requested by AWWA held up its submittal to ASA. On Jan. 3, 1952, AWWA addressed a letter to the three other sponsors requesting their approval.

A21.11—Mechanical Joints for Cast-Iron Pipe. Specification approved by Committee A21 with request for submittal (Apr. 25, 1951) to sponsors for approval. Action on this document was deferred by AWWA until discussions concerning A21.10 coating clauses were complete.

APPENDIX C

Emergency Alternate Provisions for Standard Specifications for Cold-Water Meters

Displacement Type	**AWWA C700**
Current Type	**AWWA C701**
Compound Type	**AWWA C702**
Fire Service Type	**AWWA C703**
Current Type—Propeller Driven	**AWWA C704**

These emergency alternate provisions are issued by the American Water Works Association, as of January 31, 1952, in accordance with special procedure in the interest of expediting procurement or conservation of materials during the period of national emergency. They are intended for use where they may be considered by the purchaser of the material as a permissible alternate for the specific application or use desired.

The following emergency alternate provisions listed here by section and subsection designations in the specifications, when specified, may be used as alternates in the AWWA Standard Specifications for Cold Water Meters, C700, C701, C702, C703, and C704; and affect only the requirements referred to.

C700: Sec. 3.2 External Case Bolts

Revise to read: "All external bolts or cap bolts, including washers, shall be of protective-treated iron or steel (except that, when breakable washers are used for frost protection, the bolts and washers shall be made of suitable materials). Nuts shall be of ferrous material and shall be designed for easy removal after having been long in service."

C701: Sec. 3.2 External Bolts
C702: Sec. 3.2 External Bolts
C703: Sec. 3.2 External Bolts
C704: Sec. 3.2 External Bolts

Revise to read: "All external bolts and washers shall be of protective-treated iron or steel. Nuts shall be of ferrous material and shall be designed for easy removal after having been long in service."

C700: Sec. 3.5 Register Boxes
C701: Sec. 3.5 Register Boxes
C702: Sec. 3.5 Register Boxes
C703: Sec. 3.5 Register Boxes

Add: "Register boxes and lids of aluminum, properly treated, or of suitable molded plastic may be considered as an acceptable alternate, provided the manufacturer places upon the meter adequate and lasting identification marking."

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1951

A report of the activities of the Committee on Water Works Administration for the year ending December 31, 1951, submitted to the AWWA Board of Directors on Jan. 13, 1952, by Wendell R. LaDue, Chairman.

AS outlined on pages 44–49 of the 1950 AWWA *Directory*, the present organization of the Committee on Water Works Administration provides for eighteen subcommittees grouped in four classifications. The general committee consists of the chairman, the general chairmen of the four groups and the chairmen of the various active subcommittees. Other members of the various subcommittees are not members of the Committee on Water Works Administration. Committee work has been widened by the creation of "task groups" subordinate to standing committees. The chairman of a task group is not a member of the Committee on Water Works Administration, but, in general, works within the province of the Water Works Management Division or the Water Resources Division, under which the particular task group functions.

At the 1951 Conference thirteen items stemming from the committee's activities, either directly or indirectly, were presented at the various sessions:

Committee	Work	In Journal
WWA	Open discussion of all phases of committee activities ..	—
A1.A	Paper: Local and Regional Water Supply Management	June 1951, p. 441
A1.A A.2B	Paper: Payment for Utility Changes in State Highways	July 1951, p. 496
A1.D–1	Report: Antifreeze Protection for Sprinkler Systems ..	Feb. 1952, p. 100
A2.C	Report: Compensation of Water Works Personnel	Sept. 1951, p. 675
A2.E–1	Report: Safety Practices	June 1951, p. 423
A4.B	Report: Water Rates	Sept. 1951, p. 665
A4.B	Discussion: Water Rates for Low Load Factor Water Users	—
A4.B A4.D	Papers: Residential Water Use and Family Income ...	Aug. 1951, p. 603
	Fluctuations in Water Use and Revenue	Nov. 1951, p. 877
A4.D	Paper: Characteristics of Water Use in the United States	—
A4.D–2	Report: Requirements of Various Types of Water Users	—
A4.D–2	Discussion: Seasonal Water Demands in Vacation Areas	Sept. 1951, p. 694

From the attendance, discussion and participation displayed, membership interest in administrative problems is evident and conclusive.

There follows a resume of the activities of working committees now in progress.

A1.A—Constitutional and Statutory Aspects of Municipal Water Works Organization. Because of the change of activities of its chairman, the committee's activities along basic general lines have not progressed as much as was hoped. Following evidence of need for such information, it is planned to conduct an AWWA staff survey to ascertain what powers the various states have conferred upon unincorporated population groups to organize and incur indebtedness for building public water works systems.

A1.B—Radio and Mobile Communication Facilities for Water Works. It is proposed to conduct a state-by-state survey to develop a record of all water utilities using radio and mobile communication facilities at the beginning of 1952. On February 7–9, 1951, the chairman attended a Chicago meeting of the National Committee for Utilities Radio, called to determine policies for the use of radio in civil defense.

A1.C—Water Use in Air Conditioning and Other Refrigeration. The report of this committee was published in the December 1950 JOURNAL. No comments have been filed since its publication. The model ordinance may now be advanced to standard if the committee deems such action necessary and useful. Modification of the committee report may be forthcoming. The development of demand meters is an item of present committee concern.

A1.D—Water Use in Fire Prevention and Protection. A special task group was appointed under this working committee's jurisdiction to consider the use of antifreeze mixtures in sprinkler systems. The committee reported that the procedure was well controlled by the fire protection interests and that there was no need for an AWWA standard. By direction of the Board at the Miami meeting, a digest of the practices and standards recommended by the National Fire Protection Assn. was published in the February 1952 JOURNAL.

A2.A—Public Relations. Continued promotion of better public relations methods in the industry through the distribution of issues of "Willing Water" is planned for 1952. Three issues appeared during 1951, one being devoted to information on the fluoridation of water. Parallel to "Willing Water" was the production of five issues of "Defense News," a service bulletin for information about critical materials and civil defense. Although both of these productions are essentially staff operations, the staff relies upon the advice and counsel of the Public Relations Committee in the preparation of "Willing Water" and upon various members of the Joint Committee on Critical Materials for counsel in preparation of "Defense News." An exhibit of public relations material from various water works is planned for this year's conference in Kansas City.

A2.C—Compensation of Water Works Personnel. This committee deals with a problem in which all water works men are vitally and personally involved. The survey of compensation and related practices conducted by the staff under the direction of Chairman Leon Smith was analyzed by the economic research staff in the University of Wisconsin and summa-

rized for publication in the September 1951 JOURNAL. A report was made at Miami. It is not surprising that no conclusion has been reached in the matter of wage schedules. It is not a problem for water works alone; it is a national problem which at the moment is being carried along by well organized labor groups within the heavy-industry field. In the activities of these groups, small minorities, such as water works and public employees, and smaller independent operators, are left by the wayside. Everybody is trying to get and, under present conditions, should have greater compensation. Among public employees, slow progress is being made, and an increasing lag in rates, well below local levels, results. Attitude toward "top" salaries is a key factor. Water works men must realize that it will take a great amount of personal effort by each individual in his own community to gain relief. The local pattern to effect a change is a matter for individual study and concern.

A2.D—Pension and Retirement Plans. The committee is not at present active. It reviewed the Association's retirement plan covering staff employees. Pensions are a changing field, nationally, and are being watched carefully by the chairman for new and pertinent developments.

A2.E—Task Group—Safety Practices. During 1951 a special task group under the staff leadership of R. J. Faust developed a preliminary study of then current safety programs in the water works field. This report was given at Miami and published in the June 1951 JOURNAL. Discussions of safety programs followed in several of the later section meetings. Safety in water works is part of the overall problem of safety among public employees and is of pressing concern throughout the nation. In AWWA the next step appears to be that of listing the essential points of effort from supply to the customer. Steps should be taken presently to form task groups in several areas of endeavor:

1. *Supply.* Supply would include reservoir lands, wells, reservoirs, dams, intakes, raw water conduits, and other such items.

2. *Treatment and pumping.* This aspect would include all the ordinary functions of the treatment and pumping plant, handling of chemicals, pumps, power, and other such factors.

3. *Distribution.* Distribution would include supply lines, equalizing reservoirs, elevated tanks, feeder and distribution mains, repumping stations, meters, services, garage operations, store yards, storerooms, repair shops, and other such items.

4. *Administration.* Administration would include office practices, meter reading, billing and collecting, and other such operations.

5. *Construction.* The item of construction undoubtedly can be referred quite properly to safety practices which are already well known in the construction field and are applied by contractors and state industrial commissions. This item could be deferred until the first four were completed.

Reports of these task groups would point toward the eventual production of a manual of "Water Works Safety Practices" and would be couched in such language as is usually found in the manuals of the National Safety Council or other organizations promulgating safety measures on a country-wide basis.

A3.A—Taxation and Fund Diversion. Activities of this committee were

authorized at Miami. No enthusiasm for the subject has been manifested on the part of the officers of the Management Division, although the topic is worthy of serious study and appropriate development. At least, a task group should attempt to collect data from principal cities showing disposition of water works revenues.

A3.C—Cost Trends. No activity.

A3.D—Water Main Extension Policy. The last report made by this committee was published in the August 1949 JOURNAL. It has served a useful purpose. Chairman Finch now has in development an addition to the report which will take into account the increasing problem of extensions of municipal water systems into suburban areas. Suburban growth, as indicated by the 1950 census, has created many sanitary problems, one of which is safe water supply.

A4.A—Water Department Reports. Chairman Hatcher has completed the work planned at the time the committee was established. Its report was published in the August 1950 JOURNAL. The committee should now be inactivated. It is planned, however, to set up an exhibit of water department, municipal, and other utility reports at the 1952 Kansas City Conference. This project will be exhibited under the chairman's direction.

A4.B—Water Rate Schedules. It is quite obvious that water rates present one of the most controversial subjects in which the Association is interested. Chairman Ayres and his committee continue their diligent and praiseworthy consideration of water-rate policies in U.S. cities. Their task is primarily directed toward the procedure in publicly owned systems, which, with exceptions in a few states, have no control or guidance above the local municipal level. A committee progress report was published in the September 1951 JOURNAL. The committee hopes to present a final summary report at the 1952 Conference. It should be understood, however, that a committee report on water rates published in 1952 does not dispose of the problem as either a matter of theory or of practice. The committee is working, however, with the definite objective of producing a brief statement of the primary considerations which should be evident to municipal administrative officials when they are considering the financial program of a water utility.

It is the aim of the Committee on Water Works Administration to proceed deliberately, acting upon and anticipating member interest, to establish a long-term policy of continuing activities, to maintain close cooperation with the Committee on Water Works Practice, and to encourage obvious member demand for activities as task groups of the Water Works Management and Water Resources Divisions.

Report on Publications

For the Year Ending December 31, 1951

A report on the publishing activities of the Association for the year ending December 31, 1951, submitted to the AWWA Board of Directors on Jan. 14, 1952, by Eric F. Johnson, Asst. Secretary—Publications.

DURING 1951 the JOURNAL staff was most concerned with a personnel problem—the painful process of indoctrinating two successive new aspirants to the job of assistant editor—involving delays that made issues as late as three weeks behind schedule. Although thus hampered in production, however, the JOURNAL managed to continue its growth in all respects but size.

Completion of second printings of both *Water Quality and Treatment* and the *Manual of Water Works Accounting* reflected further increases in book sales. And, though sales of specifications and reprints fell somewhat below last year's record high, that drop was more than accounted for by the fewer new specifications issued and fewer articles printed. Meanwhile, a new publication sales policy, which will, among other things, increase the discounts available to Association members, was developed and its first stage placed in effect on January 1, 1952.

A detailed report of the publication projects of the Association follows:

1. The Journal

a. *Contents.* As a direct result of the loss of editorial time in two personnel changes during the year, overall size of the JOURNAL fell 80 pages short of the 1950 total of 2,496, which it had been expected to duplicate in 1951. The number of articles in the text section was also reduced from 145 in 1950 to 118 in 1951. But, inasmuch as the drop in number was accompanied by an increase in average length of articles from 8.34 pages in 1950 to 9.12 in 1951, the loss in actual text material was not proportionate. Of the year's articles, 22 were Association and other official documents or reports and 96 were technical papers, including 32 from the Annual Conference, 44 from Section Meetings, and 20 from other sources.

Continuing to gain in size was the news and advertising section, to which 54 pages were added to accommodate 29 additional pages of advertising. On the pages facing advertisements, such features as news, book reviews, and membership changes were expanded as required. Meanwhile, the abstracts section, which is now located in the advertising pages, was maintained at about its 1950 level—126 pages in 1951 compared with 134 in 1950.

During 1952 it is planned to recoup the losses of 1951 in both overall number of pages and number of articles.

b. *Cost.* As a result of the reduction in number of pages, JOURNAL costs

during 1951 were kept well within the budget despite a sharp rise in paper costs during the year. Actually, with the 1943-based paper cost index jumping from 173 to 193 during the year, expenditures for paper exceeded budget estimates. Savings in printing and other production costs, however, held the total cost to $51,501.96 compared with the budget of $53,250.00. The fact that this cost is considerably greater than the $48,985.02 for a larger JOURNAL in 1950 is explained in some part by the increase in average number of copies printed from 9,600 in 1950 to 10,091 in 1951, but primarily by the 7½ per cent printing rate increase imposed at the end of 1950. The increased rate pushed the cost per thousand pages up from $2.01 in 1950 to $2.07 in 1951, although the smaller-size JOURNAL made possible maintenance of the cost per copy at the same 42.5¢ that prevailed in 1950. No further increase in printing rates was imposed or discussed during 1951, so 1952 budget estimates have been made on the expectation that the price line will be held for the greater part of the year.

c. *Income.* JOURNAL income from both advertising and subscriptions showed increases, while income from reprints fell off with the reduced amount of text. Although advertising revenue rose from $71,651.50 to $72,639.00, however, it fell short of the estimated yield of $74,000.00 expected from the first full year under 1950 rates. Since space sales at an average of 70.3 pages per issue—compared with 68.2 pages in 1950—did meet expectations, the reduced yield must be attributed to the increased proportion of advertising at the lower space rates earned by multiple insertions.

With a new rate schedule, approximately 12½ per cent higher, in effect as of January 1, 1952, it is expected that 1952 advertising income will reach $80,000.

2. The Directory

At the January 1951 Board meeting, it was suggested that future editions of the *Directory* be issued as two separate publications, issued in alternate years, thereby to equalize the work load on both the printer and the JOURNAL staff, to reduce the publications to a size that is economical and easily manageable, and to open another possible source of advertising income that would help pay the ever-expanding cost of the *Directory* operation. A special committee appointed by the Board at its May 1951 meeting studied the various proposals and approved the recommendation of alternate annual publications, both open to advertising at JOURNAL rates. On this basis, preliminary plans have been made to publish the Membership Lists portion of the *Directory* material in the even years, beginning with 1952, and the portion including Constitution and By-Laws, Committee Lists, Buyers Guide, and other incidental features in the odd years, beginning with 1953.

3. Specifications

During 1951, specifications for powdered activated carbon, caustic soda, and noncylinder reinforced concrete pipe were approved and published in the JOURNAL. All are now available in reprint form.

Approved during 1951, too, was a new system for designating AWWA standards which permits numbering all specifications, practice manuals, and other standards documents in an or-

derly and coherent manner. Reflecting the growth of the Association's standardization activities, this new system will promote efficiency in the future handling and sale of the documents.

Specifications sales fell off from the 1950 total of $4,649.78 to $3,601.74 during 1951. Considering the fact that the 1951 sales represent almost entirely routine distribution of old specifications rather than large quantity sales of new ones as in 1950, the 1951 total should be considered more gratifying than alarming. At any rate, sales are expected to increase again during 1952 as the new A21 documents begin to appear.

4. Journal Indexes

During the year, 30 copies of the 1881–1939 Index were sold, compared with 37 copies in 1950, leaving a balance of 171 copies in stock. In the same period, sale of 30 copies of the 1940–44 supplement, compared with 12 in 1950, left 202 copies of that publication in stock.

For another year, lack of adequate personnel time postponed progress on a new consolidated index. What started out to be a 1940–49 supplement now appears to have grown to a 1940–51 supplement, but every effort will be made to get such a publication into print during 1952. No definite proposal is being made now, as production and price schedules can be worked out only after a better estimate of the size of the volume is available.

5. Standard Methods

During 1951, 2,418 copies of the ninth edition of *Standard Methods for the Examination of Water and Sewage* were sold, bringing total distribution of this edition to approximately 17,500 copies and leaving a balance of approximately 2,000 in stock. With sales so high in its sixth year, the ninth edition has already far exceeded the most optimistic expectations.

Chairman Harry A. Faber of the Joint Editorial Board contemplates that all manuscript on the tenth edition will be completed by the end of March 1952. The material will then be turned over to an editorial coordinator, who may be able to get it into the hands of the printer by the end of the year.

6. Accounting Manual

In cooperation with the Municipal Finance Officers Assn., joint publishers with AWWA of the *Manual of Water Works Accounting,* arrangements were made during the year for a reprinting of 1,500 copies of the book to be shared equally and paid for equally by the two associations at a production cost of $1.49 per copy, only 4¢ higher than the cost of the original printing in 1938. With the approval of the Executive Committee, an order was placed with a lithographing firm in Ann Arbor, Mich., which completed its work in mid-November.

As the book was out of stock for some time before the second printing was available, sales were probably somewhat reduced. Nevertheless, 105 copies were sold, compared with 67 during 1950, leaving a balance of 731 copies of the new printing in stock.

7. Survival and Retirement Book

Sales of *Survival and Retirement Experience With Water Works Facilities* increased, from 50 copies in 1950 to 118 in 1951. This leaves 289 bound and 1,000 unbound copies of the book in stock.

8. The Quest for Pure Water

In its fourth year, sales of *The Quest for Pure Water* dropped from the 1950 total of 200 to 149, leaving 179 bound and 1,000 unbound copies in stock. It is expected that the remaining bound copies will suffice for 1952 sales, but if it appears that stock will be exhausted a proposal for binding half the unbound balance will be submitted later in the year.

9. Water Quality and Treatment

In its first full year, sales of the second edition of *Water Quality and Treatment* totaled 1,615, making total distribution 1,850, just short of exhausting the first printing. During the year, a second printing totaling 7,300 copies, of which 2,500 were bound, was completed and the type killed. The present stock of 2,534 bound and approximately 4,800 unbound can be expected to last until a third edition is required.

It may be pointed out that the manual has been adopted as a textbook in approximately 25 college courses throughout the country and will probably receive further adoptions as it becomes better known. Although it is unfortunate that water purification is not a required course for many large classes, experience with the first edition indicates that a steady school demand may be expected to continue throughout the life of the book.

10. British Manual

By arrangement with the British Institution of Water Engineers, AWWA has acted as sales agent for the *Manual of British Water Supply Practice,* thus distributing approximately 450 copies during the year to American water works men. The margin of slightly more than $1.00 per copy that accrues to AWWA on these transactions does little more than pay the cost of sales, but, by agreeing to handle the U.S. distribution, the Association has been able to make the book available at a price of $7.50, whereas, commercially handled, it would have sold for $12.50. The arrangement is being continued in 1952.

Board Action Taken

The Board approved splitting the *Directory* into annual publications to be issued in alternate years, beginning with the Membership Lists publication in 1952 and the annual containing Constitution and By-Laws, Committee Lists, Buyers Guide, and other incidental features in 1953.

Report of the Audit of Association Funds

For the Year Ending December 31, 1951

To the Members of the American Water Works Association:

The By-Laws require that the Secretary have an audit made annually of the books of the Association.

The records for 1951 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Audits have been published in the JOURNAL annually. For the past ten years they have appeared in the March issues.

Respectfully submitted,

HARRY E. JORDAN
Secretary

January 25, 1952

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1951, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1951, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—BALANCE SHEET

DECEMBER 31, 1951

Assets

Cash in Banks and on Hand		$ 39,931.44*
Accounts Receivable:		
Advertising in Journal	$7,098.75	
Reprints	76.56	
Manual—Water Quality and Treatment	325.90	
Sundry specifications	79.12	
Other	1,047.27	8,627.60
Membership Dues		364.08
Accrued Interest on Bonds		562.64
Inventories:		
Paper stock	3,988.13	
Type metal	1,393.18	
Cumulative Index (171 copies)	205.20	
Quest for Pure Water—Baker	1,354.09	
Survival and Retirement Book	1,240.39	
Manual—Water Quality and Treatment	6,328.50	
Manual of Water Works Accounting	1,089.19	
Sundry specifications	1,693.79	
Back issues—Journals—Vol. 1 to 43, inclusive (30,911 copies)	—†	
Back issues—Proceedings, 1881 to 1913, inclusive (255 copies)	—†	17,292.47
Office Equipment (less depreciation)		9,261.18
Investments at Cost (Schedule 1)		114,471.75
Deferred Expenses		3,785.78
Deposit—Airlines		425.00
TOTAL ASSETS		$194,721.94

Liabilities and Surplus

Accounts Payable	$ 1,999.18
Membership Dues—Advance Payments	38,565.43
Unearned Subscriptions to Journal	2,372.15
Payable to American Water Works Association Pension System	30,000.00‡
Reserve for Award Fund (McCord)	53.02
Surplus, per Exhibit C	121,732.16
TOTAL LIABILITIES AND SURPLUS	$194,721.94

* Canadian funds in the Bank of Montreal as at December 31, 1951 amounted to $2,172.82 which, if converted into American currency at that date, would have resulted in a loss of approximately $108.64. Had this loss been recorded, the cash in banks and the surplus would have been decreased accordingly.

† Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication. The quantity shown is in accordance with a tabulation supplied by the Association's printer.

‡ Secured by assignment of the income of United States Savings Bonds, Series G, and maturity redemption value of such bonds in the amount of $30,000.

EXHIBIT A, SCHEDULE 1—INVESTMENTS

DECEMBER 31, 1951

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1951	
Foreign Securities:					
Province of Ontario	4	$ 1,000.00	$ 732.50	$ 1,050.00*	
Canadian Victory Bonds	3	6,000.00	5,647.75	5,760.00†	
Canadian Victory Bonds	3	2,000.00	2,000.00	1,910.00†	
Hydro-Electric Power Commission of Ontario	2¾	5,000.00	5,075.00	4,175.00†	
Province of Ontario	3	2,000.00	2,[illegible].50	1,785.00†	
Hydro-Electric Power Commission of Ontario	3	2,000.00	2,020.00	1,785.00†	
Dominion of Canada, 9th Victory Loan	3	5,000.00	4,775.00	4,637.50†	
United States Securities:					
U.S. Savings Bonds:					
Series G	2½	10,000.00	10,000.00	9,790.00	
Series G	2½	10,000.00	10,000.00	9,610.00	‡§
Series G	2½	10,000.00	10,000.00	9,490.00	
Series G	2½	2,000.00	2,000.00	1,946.00	
Series G	2½	5,000.00	5,000.00	4,850.00	
Series G	2½	2,000.00	2,000.00	1,922.00	
Series G	2½	10,000.00	10,000.00	9,580.00	
Series G	2½	3,000.00	3,000.00	2,865.00	‡
Series G	2½	10,000.00	10,000.00	9,490.00	
Series G	2½	2,000.00	2,000.00	1,898.00	
Series G	2½	5,000.00	5,000.00	4,735.00	
Series G	2½	2,000.00	2,000.00	1,894.00	
Series G	2½	7,500.00	7,500.00	7,132.50	
Series G	2½	2,500.00	2,500.00	2,445.00	
Series G	2½	1,000.00	1,000.00	988.00	
U.S.A. Treasury Savings Note, Series D	1.4‖	5,000.00	5,000.00	5,199.00	
U.S.A. Certificate of Indebtedness	1⅞	5,000.00	5,000.00	5,001.83	
Excess of redemption value of U.S.A. Treasury Savings Note, Series D, over issue price			199.00		
			$114,471.75	$109,938.83	

* This security is payable in United States funds.
† These securities are payable in Canadian funds. Market value represents value in New York in United States funds.
‡ These amounts represent redemption value at December 31, 1951.
§ Redemption value and income of these securities assigned to American Water Works Association Pension System.
‖ Yield if held to maturity.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1951

Operating income:		
Annual dues	$88,813.01	
Advertising	72,395.50	
Subscriptions to Journal	7,341.65	
Convention registration fees	14,202.50	
OPERATING INCOME (carried forward)		$182,752.66

OPERATING INCOME (brought forward)		$182,752.66	
Convention—other events	4,343.09		
Water and Sewage Works Manufacturers' Assn.	7,500.00		
Interest on investments	2,120.47		
John M. Goodell prize	75.00		
Miscellaneous interest income	20.23		
TOTAL OPERATING INCOME		$196,811.45	
Publication Income:			
Manual of Water Works Accounting	323.65		
Reprints	3,349.54		
Cumulative Index	71.50		
Membership Certificates	8.80		
Proceedings and Journals	993.21		
Quest for Pure Water—Baker	599.40		
Survival and Retirement Book	303.00		
Manual—Water Quality and Treatment	7,252.70		
British Water Works Practice Manual	1,882.50		
What Price Water Booklets	4,421.15		
Sundry specifications	3,799.61		
One-half of profit from sales of Standard Methods	4,174.38		
TOTAL PUBLICATION INCOME		27,179.44	
TOTAL INCOME			$223,990.89
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$ 6,251.00		
Stenographic expense	427.35	6,678.35	
Administrative Expenses:			
Rent	8,947.50		
Moving expenses	2,820.92		
Office supplies and services	9,631.37		
Membership promotion	1,320.92		
Pension—Secretary Emeritus	2,500.00		
Contribution to Pension System	3,793.55		
Legal and accounting expenses	1,372.26		
General and special travel	1,406.05		
Federal activities	773.51	32,566.08	
Administrative Salaries		63,761.41	
Committee Expense		1,321.44	
Division and Section Expenses:			
Section—membership allotment	16,136.15		
Section—official travel	4,248.74		
Section—general expense	308.52	20,693.41	
OPERATING EXPENSES (carried forward)		$125,020.69	

OPERATING EXPENSES (brought forward)		$125,020.69	
Journal:			
Printing	37,350.53		
Production	3,880.96		
Paper	10,741.87		
Abstractors	143.03	52,116.39	
Convention:			
General	8,298.55		
Entertainment	7,982.49	16,281.04	
Membership Dues in Other Associations		542.50	
John M. Goodell Prize		75.00	
Depreciation of Office Equipment		1,221.99	
Miscellaneous Expenses		316.87	
Cost of Publications Sold:			
Manual of Water Works Accounting	$ 178.41		
Reprints	3,109.46		
Cumulative Index	36.00		
Membership Certificates	4.27		
Proceedings and Journals	13.25		
Quest for Pure Water—Baker	398.15		
Survival and Retirement Book	202.43		
British Water Works Practice Manual	1,504.84		
Manual—Water Quality and Treatment	5,911.20		
What Price Water Booklets	3,914.73		
Sundry specifications	3,026.33	18,299.07	
Development Activities:			
Public Relations	2,516.72		
Research—Compensation Water Works	1,019.45		
Defense News	2,747.82		
Operations—1950 Survey	250.20		
Seal Contest	205.15		
Water Resources Agency	1,125.00	7,864.34	
TOTAL EXPENSES			221,737.89
Net Income for the Year (Transferred to Exhibit C)			$ 2,253.00

EXHIBIT C—SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1951

Balance, January 1, 1951	$120,203.16
Add: Net income for the year, per Exhibit B	2,253.00
	122,456.16
Deduct: Write-off of uncollectible accounts receivable included in advertising income in the years 1948 and 1949	724.00
Balance, December 31, 1951, per Exhibit A	$121,732.16

American Water Works Association Pension System

BALANCE SHEET—DECEMBER 31, 1951

Assets

Cash in bank	$ 2,108.80
Accrued interest on Pension System bonds	331.25
Investments (Schedule 1)	64,000.00
TOTAL ASSETS	$66,440.05

Liabilities and Reserve for Future Benefits

Liability for refund of employees' contributions plus earned interest	2,889.39
Reserve for future benefits	63,550.66
TOTAL LIABILITIES AND RESERVE	$66,440.05

SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1951

	Interest Rate	Principal	Maturity Date
Bonds Registered in Name of Administrative Committee:			
Series G	2½%	$10,000.00*	1961
Series G	2½%	10,000.00*	1962
Series G	2½%	9,000.00*‡	1963
Series G	2½%	5,000.00†‡	1963
		$34,000.00	
Bonds Registered in Name of Association and Assigned to Administrative Committee:			
Series G	2½%	10,000.00	1953
Series G	2½%	10,000.00	1956
Series G	2½%	10,000.00	1958
		$64,000.00	

* Redemption value at December 31, 1951—$28,142.00.
† Not redeemable until June 1, 1952.
‡ Acquired in 1951.

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1951

Item	Cash	Reserve for Future Benefits	Liability for Refund of Employees' Contributions
Receipts:			
Association contributions	$ 3,793.55	$ 3,793.55	
Employees' contributions	1,070.96		$1,070.96
Interest on bonds	1,362.50	1,362.50	
	6,227.01	5,156.05	1,070.96
Disbursements:			
Investment in "G" bonds	14,000.00		
Refund of contributions plus interest	216.65		216.65
Audit and legal expense	65.00	65.00	
Office expenses	68.02	68.02	
	14,349.67	133.02	216.65
Excess of Cash Receipts Over Disbursements	(8,122.66)	5,023.03	854.31
Adjustments For Non-Cash Items:			
Interest credited to employees accounts		(49.01)	49.01
Interest accrued on bonds Jan. 1, 1951		(A) (208.34)*	
Interest accrued on bonds Dec. 31, 1951		(B) 331.25†	
		73.90	49.01
Additions to accounts for year	(8,122.66)	5,096.93	903.32
Balance, Jan. 1, 1951	10,231.46	58,453.73	1,986.07
Balance, Dec. 31, 1951	$ 2,108.80	$63,550.66	$2,889.39

* Accrued interest receivable as per balance sheet December 31, 1950.
† Accrued interest receivable as per balance sheet December 31, 1951.
()Indicates deductions.

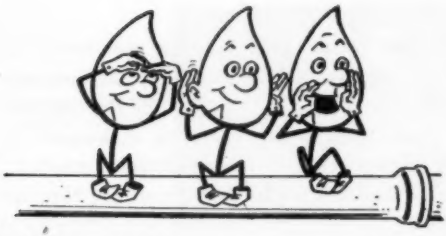
AWWA Membership Growth

Membership Statement—Year of 1951

	Active	Corporate	Munic. Serv. Subscriber	Associate	Honorary	Junior	Affiliate	Total
Total Members, Dec. 31, 1950.....	6787	719	111	324	32	48	49	8070
Change of Membership Grade.....	+10	—	—	—	+3	−13	—	
	6797	719	111	324	35	35	49	8070
Gains:								
New in 1951.....	897	113	27	28	—	19	6	1090
Reinstated in 1951.....	57	4	—	2	—	—	—	63
	7751	836	137	354	35	54	55	9223
Losses:								
Resignations and Deaths, 1951	175	12	1	6	1	3	1	199
Dropped for Nonpayment, 1951.	410	16	3	7	—	4	1	441
TOTAL MEMBERS, Dec. 31, 1951....	7166	808	134	341	34	47	53	8583
Net Gain in Year 1951.....	369	89	23	17	−1	12	5	513

Comparative Statement—Gains and Losses—23-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of dues	Gain or Loss	Total Members at End of Year
1929	314	25	118	130	97+	2,547
1930	501	39	122	134	285+	2,831
1931	203	22	123	216	114−	2,717
1932	117	22	169	297	327−	2,390
1933	168	56	159	234	169−	2,221
1934	271	66	86	122	129+	2,350
1935	565	42	85	190	332+	2,682
1936	311	53	104	218	42+	2,724
1937	515	86	122	139	340+	3,064
1938	520	59	144	140	295+	3,359
1939	578	64	122	179	351+	3,710
1940	514	58	113	212	247+	3,957
1941	480	92	116	236	220+	4,177
1942	570	59	132	233	264+	4,441
1943	769	88	130	198	529+	4,970
1944	734	92	140	171	515+	5,485
1945	543	56	111	235	253+	5,738
1946	816	79	168	324	403+	6,141
1947	933	74	143	349	515+	6,656
1948	847	81	207	347	374+	7,030
1949	1,083	75	196	323	639+	7,669
1950	852	58	128	421	361+	8,070
1951	1,090	63	199	441	513+	8,583



Percolation and Runoff

Almanacs, all full of facts, for old farmers, Texas, and the World are crowding our desk these days waiting to give us the scoop on almost anything. The *Old Farmer's Almanack* should need no introduction inasmuch as the 1952 edition is the 160th in which Abraham Weatherwise has prognosticated. More than weather and planting tables for what it calls Atomic Year 8, the *OFA,* published by Yankee, Inc., of Dublin, N.H., continues its practically age-old policy of providing more than its quarter quota of versification, philosophy, anecdotes, pleasantries, recipes, and even "photographs." Meanwhile, our friends at the Lone Star Steel Co. have sent us our first copy of the *Texas Almanac and State Industrial Guide,* a source book on THE state that has been made available since 1857 by the Dallas *Morning News* organization. Our 1952–53 edition adds up to 672 pages of information and advertising covering everything from "Abbott Reservoir" to "Zionist organizations." As for the World, that's even a little bigger than Texas—broader, in running from "AAU champions" to the "Zuyder Zee"; longer, in spanning 912 pages; and even higher, in that our copy cost us $1.75. Published annually by the New York *World-Telegram and Sun,* the *World Almanac and Book of Facts* is now in its 67th year and still a treasury of everything everywhere—except water, that is. As a matter of *fact,* only the Texans—of all people—devote any space at all to water, and that's a puny 16 pages. No wonder we must thirst for knowledge.

A hard-water problem that really is hard must be what John Kingsley, new water superintendent at Newburgh, N.Y., is bumping into in his new position with the department. At any rate, one of his first public duties was settlement of a hot argument between two of his customers concerning the city's "corrugated" water. That may explain, in terms of some of the more recent, if not the best authenticated, information, why Newburgh has been adding fluorides all these years. To dissolve the supply, obviously, or at least to straighten it out enough to permit passage through the mains.

(Continued on page 2)

(*Continued from page 1*)

The shortest board in the water works field was the one sawed off by the city council of Sioux City, Iowa, at the beginning of last month. Measuring only 39 days from establishment to abolishment, the five-member group which had been recruited with considerable care was disbanded because it had "not operated [the water system] in an efficient manner." Result of this precipitous conclusion was that control of the utility reverted to the council which took the action in December "for the best interests of the people of Sioux City and the Water Department," and reversed it in February when the council member who had successfully sponsored the board changed his mind.

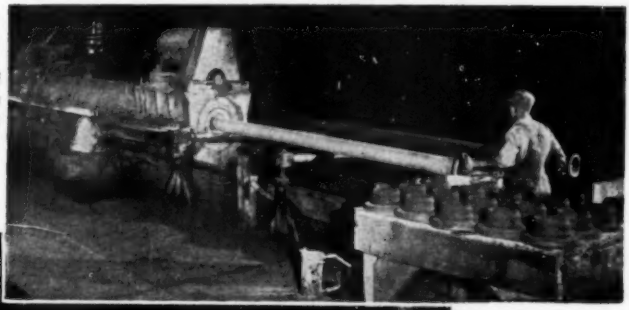
From this distance, the various knots and splinters involved are not apparent, but it does appear that someone is getting a raw end. Certainly, too, the least that should be said is that the unseemly haste hasn't won the council any prizes for dignity in municipal administration.

Manalapan ran away—Lake Manalapan, that is, a two-mile-square body of water formerly situated at Jamesburg, N.J. Where it is now we have no idea, for during the wee hours of February 12 some latter-day Lincoln, probably apprised of the presence of serface waters, decided to do some emancipation of his own by opening one of the four flood gates on the Manalapan dam. By dawn only a mudhole remained—mud in the eyes of unbelieving Jamesburgers, who saw the last of their resort trickling downstream. Not just wiped out, but blotto!

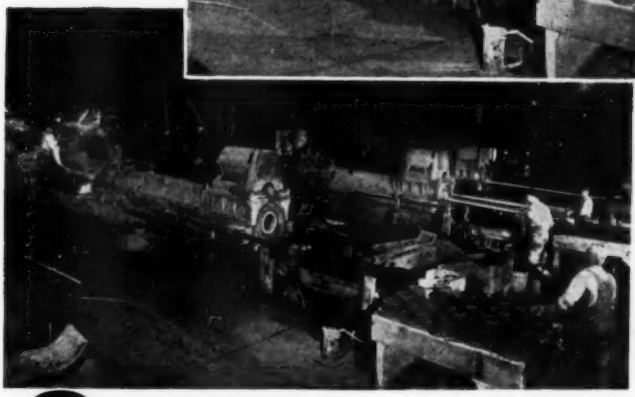
P.S.: Two days later our theory took a tumble when two fourteen-year-old boys fessed up to opening the gates in the hope of retrieving a rowboat that had drifted to the middle of the lake. Newspapers somehow failed to indicate whether or not they were successful, but, in reporting that the lake was almost full again, certainly indicated that the boys must have been successful in retrieving most of the water. Even so, they, themselves, are now subject to unemancipation, as "it is a state offense in New Jersey to let water out of a lake without a permit." The lakeletters will receive an early hearing.

You're all wet! And you know it—that your vital organs are about 70 per cent water; that your blood is 90 per cent water; that even your bones are 22 per cent water. So if you're a strapping 200-pounder and somebody smaller than you calls you "all wet," you'll know he means that 125 lb of your weight is plain water. But did you know that eggs are 70 per cent, bread 40 per cent, green vegetables 90–95 per cent, and dry crackers 25 per cent water? Even sirloin steaks were 63 per cent water. Not just ashes to ashes and dust to dust, but water to water or you'll go in a gust.

(*Continued on page 4*)



Close-up view of pulling a pipe from centrifugal casting machine.



General view showing three centrifugal machines in operation.

2 PIPE PER MINUTE

Pipe making "ain't what she used to be." It is vastly improved. More than 2 Cast Iron Pipe per minute are turned out by McWane-Pacific DeLavaud Centrifugal Pipe Foundries. At these pipe shops you see modern automatic machinery at its highest development in the pipe industry. A great centrifugal machine acts almost human. Each second trip the machine makes across its bed, a complete cast iron pipe rolls out. The machine pours its own iron and casts a pipe automatically—18′ long, a true circle in diameter and absolutely even in wall section throughout. The process is a fascinating operation. Come and see it sometime.

McWANE Cast Iron Pipe Company
Birmingham, Ala.
Pipe Sizes 2" thru 12"

Sales Offices

Birmingham 2, Ala.	P. O. Box 2601
Chicago 1, Ill.	333 North Michigan Ave.
New York 4, N. Y.	80 Broad Street
Kansas City 6, Mo.	1006 Grand Avenue
Dallas 7, Texas	1501 Mercantile Bk. Bldg.

PACIFIC STATES Cast Iron Pipe Co.
Provo, Utah
Pipe Sizes 2" thru 24"

Sales Offices

Provo, Utah	P. O. Box 18
Denver 2, Colo.	1921 Blake Street
Los Angeles 48, Cal.	6399 Wilshire Blvd.
San Francisco 4, Cal.	235 Montgomery St.
Portland 4, Oreg.	501 Portland Trust Bldg.
Salt Lake City	Waterworks Equip't Co.

(Continued from page 2)

150,000,000 years ago today a prehistoric shellfish was born; it lived four years and died in April—and that's how we know that winter water temperatures in those days averaged about eleven degrees cooler than summer temperatures, which will of course be considered most important information from the point of view of industrial water supply. And if you don't believe us, go ask Nobel Prizewinner Harold C. Urey of the University of Chicago. He's the guy who figured it out by comparing the weights of oxygen 16 and oxygen 18 in shells of that period; figured out, too, that New Jersey had about the same temperatures 60,000,000 years ago as it does now. Even if this information isn't of practical value at the moment, it certainly ought to make you feel just a bit younger—unless, of course, you're one of those who remembers when winters were colder than they are now.

Tempered metals must be used in the valves produced by the Homestead Valve Manufacturing Co. of Coraopolis, Pa. Why else would the company's letterhead note that it received the "only award for blow off, St. Louis Exposition, 1904."

(Continued on page 6)

CHECK THE WATER PLANT
THAT YOUR COMPANY NEEDS

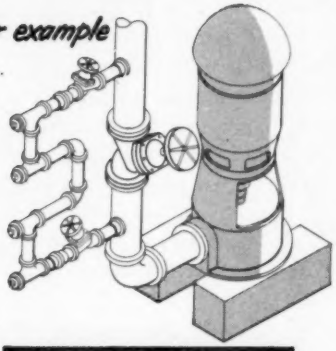
√ Coagulators
√ Demineralizers
√ Silica Removal Plants
√ Cold Process Water Softeners
√ Aerators and Degasifier Units
√ Gravity and Pressure Sand Filters
√ Greensand and Resinous Zeolites
√ Condensate De-Oiling Filters
√ Ferrosand Iron and Manganese Removal Filters
√ Gravity and Pressure Inversand Zeolite Softeners

WE SEND YOU A FREE BULLETIN WITH FULL INFORMATION ON ANY TYPE

Automatic—Semi-Automatic—Manual
Send For Bulletins
Representatives Everywhere

H&T SERVICE
There Are 34 H. & T. Sales Offices To Serve You
HUNGERFORD & TERRY, INC.
CLAYTON 5, NEW JERSEY

How's This For Solving a Valve Problem ...on Corrosive Well Water, for example



THE INSTALLATION

On outlet of well water pump supplying plant of Barr Rubber Products Co., Sandusky, Ohio. Sulphur content of water extremely high.

VALVE SERVICE RATINGS

SUITABILITY:	Just what was needed
MAINTENANCE COST:	None to date
CORROSION-RESISTANCE:	No evidence of corrosion
SERVICE LIFE:	Outlasted any 2 other valves so far
OPERATING RESULTS:	Pump shutdowns for valve repairs stopped
PRICE:	Much less than alloy valves
AVAILABILITY:	Stock item in Crane line

THE HISTORY

Valves formerly used here lasted no more than 6 months. Under constant exposure to severe erosive and corrosive effects, they failed to provide the easy operation and positive seating needed in this service. They required excessively frequent re-packing and seating maintenance.

Problem solved by replacing with Crane Packless Iron Body Diaphragm valves in main line and by-pass. Installed more than a year, they show no corrosion, no effects of service. Operate smoothly, seat tightly, with no maintenance needed to date.

THE VALVE

Crane No. 1611 Iron Body Packless Diaphragm Valves featuring separate disc and diaphragm. No packing to maintain; no stem leaks. Neoprene diaphragm used to seal bonnet only. Independent disc with neoprene insert insures positive seating even should diaphragm fail. Also fully neoprene lined valves. Many common and corrosive services. See your Crane Catalog or Crane Representative.

The Complete Crane Line Meets All Valve Needs. That's Why,
More Crane Valves Are Used Than Any Other Make!

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

(*Continued from page 4*)

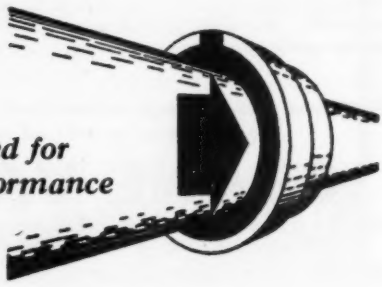
Washing out of school is bad enough, but being turned out for failure to wash is worse yet. That's exactly what happened, though, to a 13-year-old Warwick, R.I., schoolgirl who refused to take showers after her gym classes as required by school policy. It wasn't shyness either, as was first suspected, for installation of a private enclosure didn't help matters at all. Thus, it had to be just plain water, and now it had better be forgotten.

Lest we forget, however, we should point out that it's lucky for this bathingless beauty that she lives in Rhode Island rather than Alaska. Up in Fairbanks, at least, she might have been run in for sabotage instead of out of school; for, there, the city engineer recently had to call upon all loyal citizens to take at least one bath a day. His action had nothing to do with supersensitivity either—just with the city sewers that began to be affected by an extremely cold winter which sent frost penetrations as deep as 10 ft into the ground. And, of course, if people are going to keep lots of hot water running down their drains, they might better use it than waste it. Just think, though, what a bad habit they will have developed.

A color clash in Cheektowaga, N.Y., has the water utility in the midst of a cry over hue. It all started when a tint-witted couple there painted the fire hydrant abutting their property a shocking chartreuse and black to match the house. Calling it camouflage, the fire department wants the utility to make the plug ugly again. Happy with what appears to be the perfect parking trap, the police department wants to maintain the status quo. Worrying over its wards, the ASPCA is polling poochdom for the real lowdown. Meanwhile the utility has given notice that the hydrant will revert to its usual bright yellow when the maintenance department next reaches that location. Under the circumstances the least it could do by way of public relations would be to offer the colorful couple a supply of paint that would permit them then to make the home match the hydrant.

(*Continued on page 8*)

BOND-O
Homogenized
Machine blended for perfect jointing performance
NORTHROP & COMPANY, INC.
SPRING VALLEY NEW YORK



ACIPCO

When you buy anything you want the best quality you can get for your money. Our trade-mark cast on our products gives you this assurance. The trade-mark "ACIPCO" means the materials used in manufacturing our pipe are warranted to be first class and the workmanship is guaranteed to be of finest quality.

As America's largest individual cast iron pipe foundry, ACIPCO manufactures a complete line of cast iron pipe and fittings in diameters from 3" to 48", inclusive. The pipe which is made by the Mono-Cast centrifugal process is equipped with any of a wide variety of joints including Bell and Spigot, American Double-X, Molox Ball and Socket, Roll-On-Rubber Ring, Screw-Gland, and Flanged. All ACIPCO pipe is manufactured under close control to meet nationally recognized standard specifications.

Being cast iron, ACIPCO pipe enjoys an enviable reputation. Cast iron pipe has had over three hundred years of service abroad and more than one hundred years of service in the United States. It serves equally well beneath crowded city streets or in cross country installations.

Address the ACIPCO office nearest you.

AMERICAN CAST IRON PIPE COMPANY

Birmingham 2, Alabama

Dallas Houston El Paso Pittsburgh Kansas City
Chicago Minneapolis New York City Cleveland
Los Angeles San Francisco Seattle

(*Continued from page 6*)

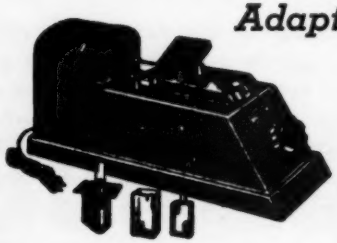
Carroll P. Bassett, president of the Commonwealth Water Co., Summit, N.J., died on Jan. 9, 1952, at the age of 89. A graduate of Newark Academy, he received a civil engineering degree from Lafayette College in 1883 and a doctorate in 1888. He also obtained a degree in mining engineering and spent some time in study and travel in Europe. As an engineer he designed water, sewage and power systems and soon acquired a reputation in these fields. After a water shortage at Summit in 1889 he headed a group that set out to obtain an adequate supply, and the founding of the Commonwealth company was a result of this effort. Always active in technical and other organizations, he was president of the New Jersey Sanitary Assn. in 1892. His AWWA membership dates back more than 40 years to 1909.

Willis Harry Badley has joined Neptune Meter Co. and will assist A. D. Mars Jr. in representing the company in Montana, Colorado, Wyoming, Idaho and Utah. A student of chemical engineering at Kansas State College and a veteran of four years with the Air Force, he is the son of Harry W. Badley, Neptune's Kansas representative.

(*Continued on page 10*)

KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

THE WORM THAT TURNS THE LOCK THAT LIFTS!

A strong, effective lock, insuring safety for the meter and the pedestrian.

A powerful screw-jack with handle to force the lid open even when frozen down.

When it comes to opening meter boxes that are sealed shut with ice or dirt, nothing beats the Ford Meter Box Cover fitted with the Lifter Worm Lock. All it takes is a simple twist of the wrist. The powerful worm leverage does the rest and the key serves as a handle for lifting the lid. Send today for full information about this and other time-saving Ford meter servicing devices.

THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

FORD

Wabash, Indiana

(*Continued from page 8*)

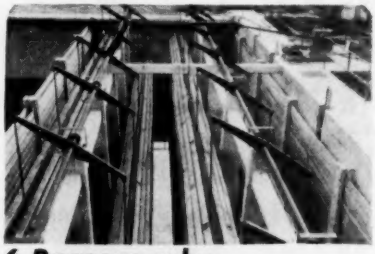
"It's as good as done," said the *New Yorker* last November in a remarkably kind comment on the following ad that appeared in *Sewage Works Journal:*

Is there a professional friend or associate for whom it is always difficult to select a suitable nonpersonal Christmas gift? Here's one suggestion that will answer the problem for you—give him a copy of the *20 Year Index to Sewage Works Journal.*

"If you gotta give, you gotta give" is more what we expected. "Chic Sale, perhaps?" is what we feared. Certainly Wisely got off well.

The seventh annual Purdue Industrial Waste Conference is scheduled to be held on May 7–9 at the Purdue Memorial Union, Lafayette, Ind. Approximately 50 technical papers are scheduled for presentation. Further information can be obtained from Don E. Bloodgood, professor of sanitary engineering at the university. Announcement has also been made that the proceedings of the previous year's conference are now ready and may be obtained at a cost of $1.25 per copy from Dean A. A. Potter, Executive Bldg., Purdue Univ., Lafayette, Ind.

(*Continued on page 12*)



6 Reasons why
WALKING BEAM FLOCULATION
is now specified by water works engineers.

1. Eliminates troublesome underwater bearings.
2. Eliminates expensive dry well construction.
3. All bearings accessible for inspection and lubrication.
4. Produces quick responsive floc formation.
5. Longer filter runs.
6. A saving in alum.

Write today for Bulletin 451 and a list of water purification plants that have gone modern.

STUART CORPORATION
516 N. CHARLES ST., BALTIMORE 1, MD.

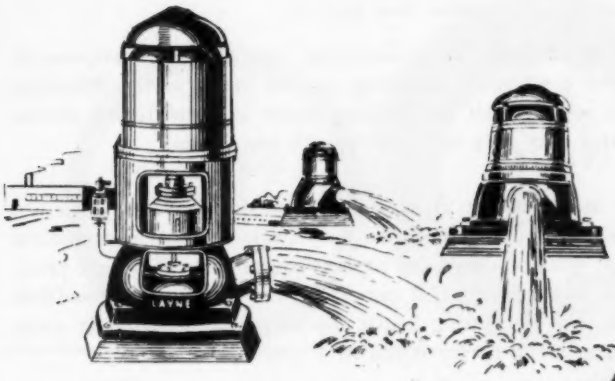
Standard With Thousands of Water Works Men For Over 40 Years

DARLEY MAGNETIC DIPPING NEEDLE $17.50

with 3 section telescoping handle $22.25

Write Today for 68-Page Catalog

W. S. DARLEY & CO., Chicago 12



For the Years to Come

The building of Layne Wells and Pumps involves the finest skill in engineering plus the very best in all materials used. This means that Layne Wells and Pumps always give satisfactory service for now, and the years to come. And added to skill and quality is the unmatched experience of Layne in the field of well water development.

Today as never before a water supply must be rugged enough to give service day after day on around the clock schedule. And the advantages of experience is your best assurance of that Layne builds them right.

Let your next installation be a Layne. No other can match their excellent performance records.

NEW CATALOG

—A new 52-page catalog on Layne Well Water Systems will be sent on request.

LAYNE & BOWLER, INC.
General Offices, Memphis 8, Tenn.

Layne
WATER SUPPLY **WELLS & PUMPS**

(*Continued from page 10*)

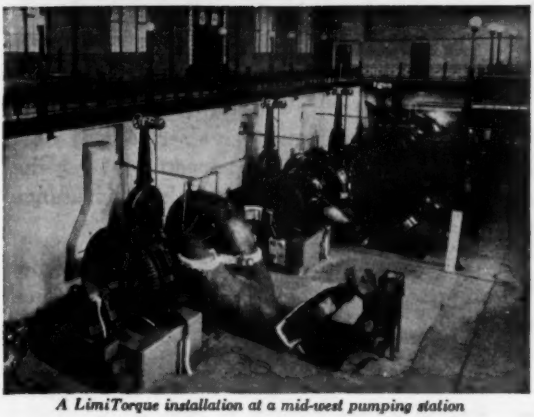
Gambling is ill-advised—John Gambling, that is, the TV impresario who recently issued a warning, following a main break in the Elizabeth water distribution system, that all drinking water in New Jersey should be boiled. And that was even before Elizabeth was queen.

A neoprene maintenance coating has been developed by E. I. du Pont de Nemours & Co., and is intended for exterior corrosion protection on tanks, structural steel, pipelines and process equipment. The new product is the result of developments that permit solvent solution of a modified neoprene polymer, thus permitting brush application, and curing at room temperatures after addition to the liquid of a special accelerator.

Carleton B. Edwards has been elected president of Reilly Tar & Chemical Corp. and Republic Creosoting Co., succeeding Peter C. Reilly, who died on January 4 (*see* January P&R, p. 12). A veteran of 31 years with the Reilly interests, Edwards has successively been research chemist, director of research, production manager, and—for the last ten years—general manager of the companies.

(*Continued on page 14*)

LIMITORQUE ..for SAFE, DEPENDABLE operation of valves

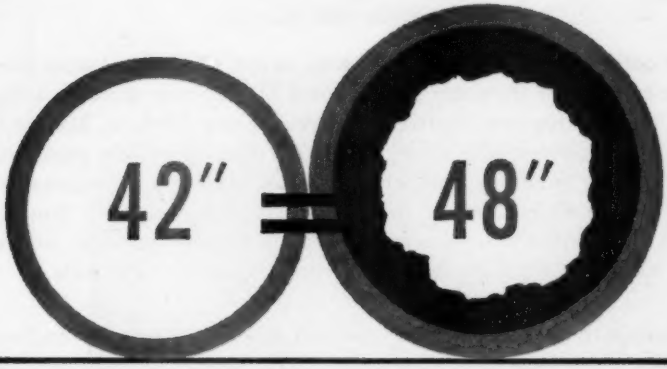


A LimiTorque installation at a mid-west pumping station

Limitorque operates by the "push of a button" from either remote or nearby control panel . . . prevents damage to stem, seat, disc, gate or plug, because Torque Seating Switch limits the torque and thereby shuts off the motor before trouble can occur . . . actuated by any available power source . . . fits all types of valves. LimiTorque may be obtained through valve manufacturers.

Write for catalog on your Business Letterhead, please.

PHILADELPHIA GEAR WORKS, Inc.
ERIE AVENUE and G STREET, PHILADELPHIA 34, PA.
New York • Pittsburgh • Chicago • Houston • Lynchburg, Va.
In Canada: William and J. G. Greey Limited, Toronto



When 42" is as big as 48" you need... National

Yes, it's true!

Even a small amount of incrustation will reduce the carrying capacity of a 48" main to that of a clean 42" main.

The more your mains are clogged, the less capacity they have and the resulting reduced pressures increase pumping costs and fire hazard.

Take the easy way out—call National. Then, if your mains need cleaning we'll do the job quickly and effectively with little or no interruption in service.

Why not let our engineers find out what condition your water mains are in?

There's no obligation!

NATIONAL WATER MAIN CLEANING COMPANY
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(*Continued from page 12*)

Wooling Water is what it is now in Akron, Ohio—ever since Wendell LaDue came home from the International Stock Show sporting a big red ribbon representing second prize in the Wool Show Division, Market Wool Class. No, Wendell hadn't been letting his beard grow; the prize actually went to sheep from the flock of more than 1,000 that is maintained on Akron's watershed as part of its soil conservation program. Not "over" but "in" the public eye, this wool has been another point in convincing Akron that everything its water department does is "yard-wide."

George H. Dann, formerly general superintendent and engineer of the Philadelphia Suburban Water Co., Bryn Mawr, Pa., has been elected vice-president of the organization.

Clifford McKibbin Jr., formerly city manager of Sanford, Fla., has joined the consulting firm of Smith and Gillespie of Jacksonville, Fla. A mechanical engineer with experience in pumping and power plants, he was city manager of Winter Park, Fla., before coming to Sanford three years ago.

(*Continued on page 16*)

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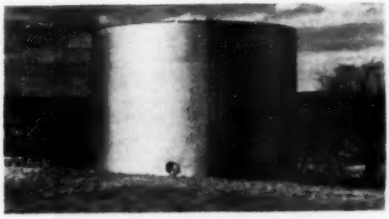

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(Continued from page 14)

Water supply problems were featured at a recent sectional meeting of the Hydrology and Meteorology Sections of the American Geophysical Union, held February 8 and 9 at the California Inst. of Technology, Pasadena. Among topics discussed were cloud seeding, California water quality problems, salt water intrusion, silting in Lake Mead and the Colorado River, aquifer recharge by reclaimed waste waters, and chemical pollution caused by normal domestic water use.

David J. Purdie, sales engineer and district office manager of the New York branch office of Builders-Providence and affiliated companies, received a 40-yr service award in recognition of his long association with the organization.

The "Mathematical Computing Service" has been organized to supply complex engineering calculations in the hydraulic field and provide both the mathematical formulation and solution of hydraulic problems on the basis of given data. The consulting group is located at 105 Court St., Room 604, Brooklyn 2, N.Y.

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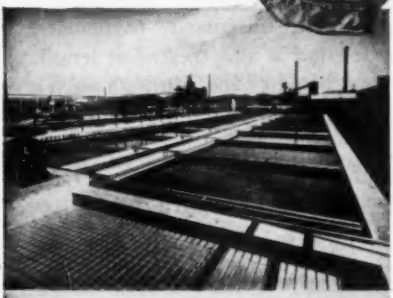

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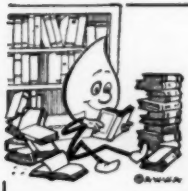

The Reading Meter

Fluid Flow in Pipes. *Clifford H. McClain. The Industrial Press, 148 Lafayette St., New York (1952) 123 pp.; $3*

"A clear-cut summary of modern theory in the flow of liquids and gases through piping and ducts, with practical applications and detailed worked-out examples," this book is subtitled. As a hydraulic text it is doubtless as elementary as it claims to be, but the average reader will not find the going simple for all of that. Those properties of fluids that affect their flow are discussed—particularly viscosity—and the influence of pipe friction is also treated at length. A special section deals with water flow in pipes, and through valves, fittings and orifices.

Water for Industry. *Technical Bulletin No. 17, Urban Land Institute, 1737 K St., NW, Washington 6, D.C. (Nov. 1951) 32 pp; paperbound; $5*

There is a lot of room for the type of "review of water resources affecting industrial location" that this publication purports to be. Too much room apparently, for it is difficult to find any place that the bulletin may be said to fill. And at $5 for what amounts to an 8-page summary of the nation's water conditions, state by state, we just can't see it.

Since the booklet does obviously recognize the vital importance of water supply, industrialists may find it worthy of an excess profit or two. For the underpaid and underprivileged water worker, it can by no means be recommended.

Engineers' Illustrated Thesaurus. *Herbert Herkimer. Chemical Pub. Co., Inc., 212 Fifth Ave., New York 10, N.Y. (1952) 572 pp.; $6*

As the name implies, the *Engineers' Illustrated Thesaurus* is a collection of engineering drawings arranged according to subject matter. The text is limited to descriptive labels of the more than 8,000 illustrations, and the value of the collection lies in the diagrams

(*Continued on page 20*)

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The Reading Meter

(*Continued from page 18*)

themselves, which serve to remind the engineer of the variety of methods available for working out any particular problem. For operating details, of course, more specialized sources would have to be consulted.

There are two great drawbacks to the volume. The quality of the drawings, which frequently were reproduced from originals not suitable for the sort of reduction required in a book of this type, is irregular, and many details are obscure. Also, despite the large number of drawings included, the book suffers from the fact that there are not more of them, or at least a better selection in some categories.

For example, although nineteen "general-purpose shut-off valves" have been shown, at least fifteen of them are foreign models, and the multitude of important domestic types have been ignored. Also, although air blowers are not normally the concern of the water works industry, one wonders why half the space devoted to this topic is occupied by early types, which presumably have little more than historical interest now.

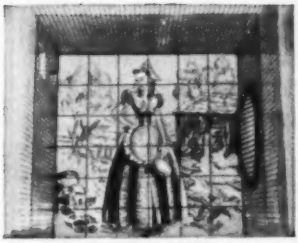
In general, the book may be described as novel and useful in conception, but lacking somewhat in execution.

Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users. *Handbook 49, National Bureau of Standards, Washington, D.C. (1951) 11 pp.; paperbound; 10¢ from Superintendent of Documents, Washington 25, D.C.*

The fact that studies into the disposal of radioactive isotopes have taken into account the hazards to sewage treatment plant personnel is of some comfort, although no protective method relying entirely upon dilution can be greeted with real enthusiasm by processors of the receiving waters. The quantitative calculations appear to have been made realistically and conscientiously, but it is hard to understand why individual hospitals are not urged to ask sewage plant personnel for accurate low-flow figures and possible information on other radioactive wastes being discharged into the sewer system. Without such information, a possibility of excessive concentrations must always exist.

(*Continued on page 22*)

Increased Supply for Springs Mills...



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control gallery

MECHANICAL EQUIPMENT BY ROBERTS FILTER MFG. CO. DARBY, PENNA.

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The Reading Meter

(*Continued from page 20*)

Cathodic Protection. *Report of Correlating Committee on Cathodic Protection. National Assn. of Corrosion Engineers, 919 Milam Bldg., Houston 2, Tex. (1951) 33 pp.; paperbound; 50¢*

This report of the correlating committee sponsored by a host of organizations, including AWWA, consists of a foreword and four cathodic protection bulletins that are listed below, together with the dates of their publication in the JOURNAL AWWA:

BUL. No.	TITLE	IN JOURNAL
I	Management Information on Cathodic Protection of Buried Metallic Structures Against Corrosion	May 1948, p. 485
II	Cathodic Protection Notification Procedures	Sept. 1949, p. 845
III	Cathodic Protection Technical Practices	Nov. 1951, p. 883
IV	Joint Cathodic Protection Systems	Sept. 1949, p. 852

For their publication in consolidated, booklet form, the four bulletins were re-edited to minimize overlapping and duplication.

Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipments. *Simplified Practice Recommendation 247–52, U.S. Dept. of Commerce, Washington, D.C. (1952) 308 pp.; paperbound; 75¢ from Superintendent of Documents, Washington 25, D.C.*

Prepared in cooperation with the Bureau of Standards, this simplified practice recommendation outlines accepted procedures for the safe and economical packaging of steel products. A section on tubular products, including water pipe, is provided.

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Sam J Kassouf and Edward J. Kassouf, of The Kassouf Company, discuss one of the blueprints for the 5700-ft Section A of Belvoir Boulevard water main.

By way of augmenting its water-distribution system, the City of Cleveland recently embarked on a vigorous expansion program which included the construction of three water towers, two auxiliary pumping stations and a system of new water mains. Construction of one of the new mains is shown in the accompanying photographs. The pictures were taken on Section A of the Belvoir Boulevard line, for which Bethlehem furnished 5700 ft of 48 in. tar-enameled steel pipe. The contractor was The Kassouf Company, Cleveland.

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Membership Changes

NEW MEMBERS

Applications received January 1 to January 30, 1952

Abilene, City of, Perry C. Peine, City Mgr., City Hall, Abilene, Kan. (Corp. M. Jan. '52) *M*

Arbogast, Clarence Carl, Mgr., The Ashtabula Water Works Co., Ashtabula, Ohio (Jan. '52) *MPR*

Avilla Water Dept., D. D. Strock, Supt., Avilla, Ind. (Corp. M. Jan. '52) *MP*

Baker, Orville E., *see* Southwest Water Co., Inc.

Baxter Springs Water Works, C. L. Wheeler, Water Supt., Baxter Springs, Kan. (Corp. M. Jan. '52)

Beatty, Arthur L., Sr. Sanitarian, Water & Sewage Section, Los Angeles County Health Dept., 808 N. Spring St., Los Angeles, Calif. (Jan. '52)

Bellinger, Harry O'B., City Engr., City Hall, Columbia, S.C. (Jan. '52) *MPR*

BeVier, B. V., *see* Salem (Ore.) Municipal Water Com.

Blackwell, Delber, Project Engr., Black & Veatch, 4706 Broadway, Kansas City 2, Mo. (Jan. '52) *MPR*

Bradac, Charles, *see* Heinz, H. J., Co.

Brady, Thomas J., Assoc. Valuation Engr., Water Bureau, Public Service Com., 233 Broadway, New York 7, N.Y. (Jan. '52) *M*

Brewer, Claude A., Supt., Water Dept., Parsons, Kan. (Jan. '52) *MPR*

Brunton, Robert L., City Mgr., City Hall, Milton-Freewater, Ore. (Jan. '52)

Colebaugh, David C., Jr., Research Chemist, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa. (Jan. '52) *P*

Collingwood, William T., *see* El Paso (Tex.) Electric Co.

Coughlin, N. L., Vice-Pres. & Mgr., San Bernardino Water Utilities Corp., 3170 State St., San Bernardino, Calif. (Jan. '52).

Creel, Henry Grady, Jr., City Engr. & Mgr. of Utilities, 221 N. Elm St., Denton, Tex. (Jan. '52) *M*

De La Rosa, Anatolio, Civ. Engr., Comision de Fomento Nacional, 354 Ave. de Los Martires, Camaguey, Cuba (Jan. '52) *MPR*

Delaware Water Dept., L. T. Hagerty, Supt., City Hall, Delaware, Ohio (Mun. Sv. Sub. Jan. '52)

Dix, Porter E., Asst. Mgr., Transite Pipe Section, Johns Manville Sales Corp., Merchandise Mart Plaza, Chicago 54, Ill. (Jan. '52)

Dodge, Peter Cook, Jr. Asst. San. Engr., Bureau of San. Eng., State Dept. of Health, 2411 N. Charles St., Baltimore 18, Md. (Jan. '52) *P*

Dorsey, B. R., Mgr., Venezuela Gulf Refining Co., Apdo. 16, Barcelona, Venezuela (Jan. '52) *P*

Duebler, F. C., Supt., Water & Electric Dept., Shawano, Wis. (Jan. '52) *M*

El Paso Electric Co., William T. Collingwood, Results Engr., Box 982, El Paso, Tex. (Corp. M. Jan. '52) *PR*

Eubanks, Stafford H., Asst. Storekeeper, General Waterworks Corp., 701 Main St., Pine Bluff, Ark. (Jan. '52) *MPR*

Fenton, William Lee, Jr., Water Tender, City Utilities, Nebraska City, Neb. (Jan. '52) *MPR*

Filicky, Joseph George, Research Chemist, West Virginia Pulp & Paper Co., Tyrone, Pa. (Jan. '52) *P*

Flockhart, John S., Chief Engr., Dept. of Public Works, Room 400, City Hall Annex, Newark 2, N.J. (Jan. '52) *M*

Ford, Richard L., Sales Engr., Rockwell Mfg. Co., Box 573, Oswego, Ore. (Jan. '52)

Fornetti, David J., *see* Iron Mountain (Mich.) Water Dept.

(*Continued on page 32*)

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(*Continued from page 30*)

Fuller, O. M., Supt., Board of Public Works, Gaffney, S.C. (Jan. '52)

Gassner, Berl Joe, Supt., Water Dept., Brookshire, Tex. (Jan. '52) *M*

Glasheen, Robert William, Supt., Water Dept., Room 17, Memorial Bldg., Athol, Mass. (Jan. '52) *MPR*

Green, Grant, Supervisor of Bookkeeping, Munic. Water Works, Robinson Memorial Auditorium, Little Rock, (Jan. '52) *M*

Guthrie, Bradley L., Supt. of Filter Plant, Brown County Water Improvement Dist. No. 1, 113 E. Baker St., Brownwood, Tex. (Jan. '52) *P*

Gutierrez Bolivar, Oscar, 2 No. 303 entre 13 y 15, Vedado, Havana, Cuba (Jan. '52) *M*

Hagerty, L. T., *see* Delaware (Ohio) Water Dept.

Haseltine, Theodore Raymond, Sr., Cons. Engr. & Partner, The Chester Engrs., 210 E. Parkway, Pittsburgh 12, Pa. (Jan. '52) *P*

Hatchett, James Lawrence, Chemist, U.S. Geological Survey, Water Resources Div., Quality of Water Branch, 918 W. Park, Albuquerque, N.M. (Jan. '52) *R*

Hegarty, Maurice V., Chief of Operations, Jamaica Water Supply Co., 161–20—89th Ave., Jamaica 1, N.Y. (Jan. '52) *MPR*

Heinz, H. J., Co., Charles Bradac, Analytical Chemist, 1062 Progress St., Pittsburgh, Pa. (Corp. M. Jan. '52) *PR*

Hem, John D., Dist. Chemist, U.S. Geological Survey, Box 443, Albuquerque, N.M. (Jan. '52) *R*

Howell, Ralph C., Water Dist. Field Supt., Dept. of Water & Power, 16223 Covello St., Van Nuys, Calif. (Jan. '52)

Hyndshaw, Albert Y., Research Chemist, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa. (Jan. '52) *P*

Iron Mountain Water Dept., David J. Fornetti, Supt., City Hall, Iron Mountain, Mich. (Corp. M. Jan. '52) *MP*

Irwin, Thomas B., Sales Agent, U.S. Pipe & Foundry Co., 510 Bryant Bldg., Kansas City, Mo. (Jan. '52)

Leonard, Alfred C., Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York 18, N.Y. (Jan. '52) *P*

Lewis, R. C., *see* Southwestern Ohio Water Co.

Lezotte, Evered, *see* Munising (Mich.)

Linde, Robert J., Chemist-Bacteriologist, Water & Sewer Dept., Tulsa, Okla. (Jan. '52) *P*

Marek, Glenn E., *see* Rochester (Minn.) Public Utilities

Marshall, Herbert, Supt. of Utilities, Kimball, Neb. (Jan. '52) *M*

Maseda Menendez, Jose, Student, 17 entre D y E No. 509, Vedado, Havana, Cuba (Jan. '52) *R*

Maxwell, Eugene C., Sales Repr., Barrett Div., Allied Chemical & Dye Corp., 1220 S. Fillmore St., Denver, Colo. (Jan. '52) *MPR*

McAuliffe, Joseph J., *see* North Vernon (Ind.) Water Dept.

McEwen, Stuart J., Mgr., Public Utilities, Palmerston, Ont. (Jan. '52) *M*

Meyer, Godfrey M., Comr., Passaic Valley Water Com., 218 Washington Ave., Clifton, N.J. (Jan. '52)

Meyer, Joe R., Sales Engr., Tar Products Div., Koppers Co., Inc., 350—5th Ave., New York, N.Y. (Jan. '52)

Meyerhoff, Charles W., Supervisor, Water Works, 33 N. Central Ave., Ramsey, N.J. (Jan. '52)

Moir, Clifford A., Town Clerk & Treas., Dartmouth, N.S. (Jan. '52) *M*

Moore, Thomas, Jr., Supt., Munic. Utilities, Lowell, Mich. (Jan. '52) *M*

Munising, City of, Evered Lezotte, Supt., Public Works & Utilities, Box 272, Munising, Mich. (Mun. Sv. Sub. Jan. '52) *M*

Munson, Edward W., Director of San., Monterey County Health Dept., 154 W. Alisal St., Salinas, Calif. (Jan. '52) *P*

North Vernon Water Dept., Joseph J. McAuliffe, Treas., North Vernon, Ind. (Corp. M. Jan. '52) *M*

Norton, John C., Engr. & Owner, John C. Norton & Assoc., 415—5th St., Traverse City, Mich. (Jan. '52) *P*

(*Continued on page 34*)

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(*Continued from page 32*)

Oeffner, Thomas Oliver, Research Chemist, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa. (Jan. '52) *MP*

Olson, Arnim Gilbert, Supt., Water & Electric Dept., 510 Greenbay Rd., Winnetka, Ill. (Jan. '52) *MP*

Pardee, George C., Gen. Counsel, Metropolitan Utilities Dist. of Omaha, 402 Utilities Bldg., Omaha, Neb. (Jan. '52) *M*

Parlin, Frederick F., Supt., Leadville Water Co., Leadville, Colo. (Jan. '52)

Parsons, Thomas Cade, Supt., Water Works, Box 143, Natchez, Miss. (Jan. '52) *M*

Patterson, T. A., Supt., Brookside Water Co., 117 E. Pikes Peak, Colorado Springs, Colo. (Jan. '52) *M*

Perkins, Carl K., N.Y. Dist. Sales Mgr., Builders-Providence, Inc., 20 Vesey St., New York 7, N.Y. (Jan. '52) *P*

Philpott, James Henry, Cons. Engr., 631 E. Sunrise Blvd., Fort Lauderdale, Fla. (Jan. '52) *P*

Plana Asteinza, Luis, 23 No. 960 entre 2 y 4, Vedado, Havana, Cuba (Jan. '52) *R*

Poehlein, Russell F., Clerk-Treas., Tell City, Ind. (Jan. '52) *M*

Pope, Walter Joseph, Assoc. Engr., Baldwin & Cornelius Eng. Co., 117 W. Sunrise Highway, Freeport, N.Y. (Jan. '52) *PR*

Raymond, Allan E., Acting Dist. San. Engr., 18 S. Market St., Johnstown, N.Y. (Jan. '52) *P*

Redfern, Donald B., Cons. Engr., Proctor, Redfern & Laughlin, Thistletown, Ont. (Jan. '52)

Renn, Charles Easterday, Prof. of San. Eng., Johns Hopkins Univ., 200 Whitehead Hall, Baltimore 18, Md. (Jan. '52) *PR*

Renz, William Eugene, Jr., Salesman, Neptune Meter Co., 4048 W. Taylor, Chicago, Ill. (Jan. '52)

Robinson, John Hamilton, San. Engr., Black & Veatch, 4706 Broadway, Kansas City 2, Mo. (Jan. '52) *P*

Rochester Public Utilities, Glenn E. Marek, Gen. Mgr., 425—2nd Ave., N.E., Rochester, Minn. (Corp. M. Jan. '52) *M*

Salem Municipal Water Com., B. V. BeVier, Engr.-Supt., Municipal Bldg., Salem, Ore. (Corp. M. Jan. '52) *MP*

Savio, Aldo P., Civ. Engr. & Partner, Mark Thomas & Co., 18 N. San Pedro St., San Jose 10, Calif. (Jan. '52) *R*

Scanlan, Charles J., Comr., Passaic Valley Water Com., 421—12th Ave., Paterson, N.J. (Jan. '52)

Schroeder, Joseph B., Repr., Hersey Mfg. Co., 1231 N.W. Hoyt St., Portland, Ore. (Jan. '52)

Senseny, Robert M., Salesman, Johns Manville Sales Corp., 407 S. 25th St., South Bend, Ind. (Jan. '52)

Shepard, Jack Richard, Eng. Supervisor of Light & Water, Dept. of Public Utilities, 3854 Mulberry St., Riverside, Calif. (Jan. '52) *MR*

Smith, Bernard Fletcher, Forest Mgr., The Newport News Waterworks Com., City Hall, Newport News, Va. (Jan. '52) *R*

Smith, Raleigh A., Jr., Vice-Pres. & Engr., Greenfield Utilities Corp., 6409 Paine, Houston 22, Tex. (Jan. '52) *M*

Southwest Water Co., Inc., Orville E. Baker, Gen. Mgr., Box 5103, Tucson, Ariz. (Corp. M. Jan. '52) *MP*

Southwestern Ohio Water Co., R. C. Lewis, Gen. Mgr., 7617 Reading Rd., Cincinnati 37, Ohio (Corp. M. Jan. '52) *M*

Stout, Maurice C., Development Engr., Indianapolis Water Co., 3905 Kenwood Ave., Indianapolis 8, Ind. (Jan. '52)

Strock, D. D., *see* Avilla (Ind.) Water Dept.

Thackaberry, Harold L., Dist. Supt. of Repairs, Dept. Water Supply, Gas & Electricity, New York, N.Y. (Jan. '52) *M*

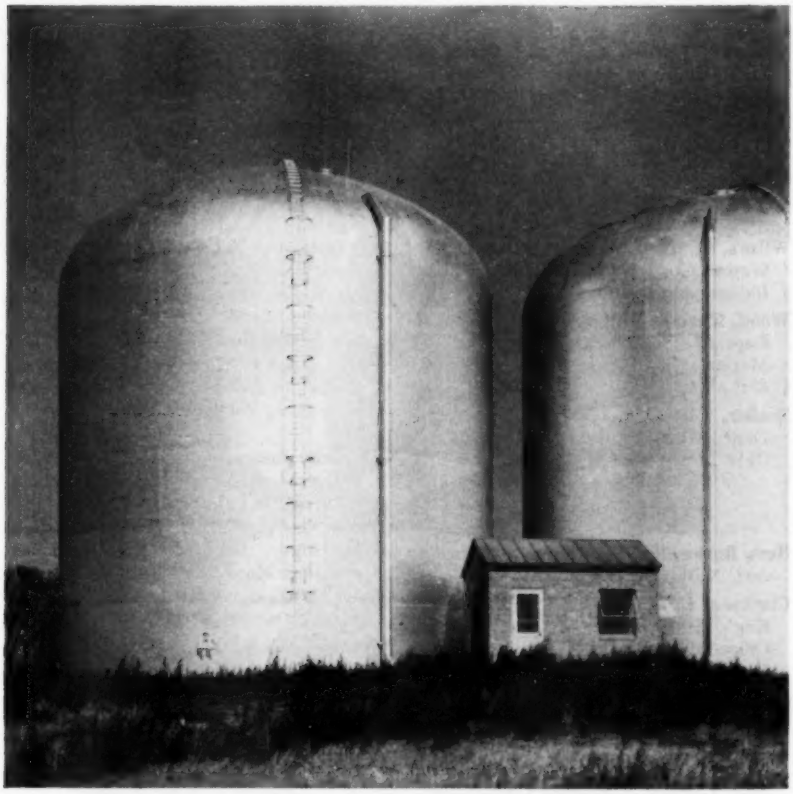
Timmers, Harold J., Jr., Sales Engr., Johns Manville Sales Corp., 1211 N. Marriman St., Appleton, Wis. (Jan. '52)

Tower, R. H., Pres., Soft Water Supply Co., 214 N. 5th St., Rockford, Ill. (Jan. '52) *PR*

Ulmer, Marion R., Asst. to Mgr., Water & Light Plant, 411 Union St., Jonesboro, Ark. (Jan. '52) *MP*

Wasson, Roland H., Mgr., Pump Sales Dept., Fairbanks, Morse & Co., 1550 S. State St., Chicago 5, Ill. (Jan. '52) *M*

(*Continued on page 36*)



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SAN FRANCISCO	HOUSTON	ATLANTA	HAVANA	WASHINGTON

(Continued from page 34)

Weagraff, Orville A., Supt., Water & Light Dept., 41 Main St., Salamanca, N.Y. (Jan. '52) *M*

Wheeler, C. L., *see* Baxter Springs (Kan.) Water Works

White, Harry Weldon, Filter Plant Supt., General Waterworks Corp., Pine Bluff, Ark. (Jan. '52)

Wilcox, F. Earl, Sr. Engr., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6, Ind. (Jan. '52)

Wood, Thomas Miller, Jr., Chief Design Engr., J. B. McCrary Eng. Corp., 22 Marietta St., Atlanta, Ga. (Jan. '52) *MP*

Zoeller, Cletus A., Office Engr., Water Dept., Municipal Bldg., Oklahoma City, Okla. (Jan. '52) *M*

REINSTATEMENT

Burt, Burke, 1205 S. Monroe St., Tucumcari, N.M. (July '42) *P*

Clarkson, L. M., Director, Public Health Eng., State Dept. of Health, State Office Bldg., Atlanta 3, Ga. (Aug. '29) *P*

Drumb, Elmo Clifton, City Engr., Denison, Tex. (Apr. '51) *M*

Edwards, Gail P., Prof. of San. Chemistry, New York Univ., University Heights, New York 53, N.Y. (July '34)

Growdon, H. C., Supt., Water Works, 728—2nd St., Portsmouth, Ohio (Apr. '41)

Havlina, Ernest J., Civ. Eng. Asst., 1735 W. 69th St., Los Angeles 44, Calif. (Oct. '45) *MP*

Hefling, A. W., Cons. Engr., 209 W. 23rd St., Hutchinson, Kan. (Oct. '49)

Mallmann, Walter Leroy, Dept. of Bacteriology & Public Health, Michigan State College, East Lansing, Mich. (Jan. '38) *Fuller Award '41. P*

Meridian, City of, George J. Roark, City Mgr., Meridian, Miss. (Corp. M. July '49)

Moses, James E., Gen. Foreman, Water & Sewer Dept., City Hall, Durham, N.C. (Jan. '41)

Nisbet, George A., Supt., Water Dept., Box 554, Palisade, Colo. (Oct. '34)

Taylor, Harry, Civ. Engr., Dept. of Water Supply, Gas & Electricity, 605 Municipal Bldg. Brooklyn, N.Y. (July '44)

LOSSES

Deaths

Cleveland, E. A., Chief Comr., Greater Vancouver Water Dist., 1303 Sun Bldg., Vancouver, B.C. (Mar. '24) *Fuller Award '46. MP*

Coughlin, L. J., Supt., San Bernardino Water Utilities Corp., 3170 State St., San Bernardino, Calif. (Oct. '38) *M*

Fague, Hugh F., Supt. of Constr. & Maint., Bureau of Water Works, 1900 N. Interstate Ave., Portland 12, Ore. (May '33) *M*

McAmis, James W., Supt., Water Works & Sewerage, Greenville, Tenn. (Sept. '21) *MPR*

Taber, George A., Pres., Pennell, Dearborn & Hovey, Inc., 1000 N. Main St., Reading, Mass. (June '12)

Tait, William, Mgr., Pubilc Utilities, Picton, Ont. (Apr. '34) *M*

Watson, W. S., Supt., Board of Public Works, Water Dept., City Hall, Hannibal, Mo. (Jan. '40) *M*

White, Ira E., Supt., Water Dept., Municipal Bldg., Parsons, Kan. (Jan. '45) *M*

Resignations

Allen, Walter B., Factory Mgr., Art Concrete Works, 2400 Adeline, Oakland 7, Calif. (Oct. '49)

Bidlack, Floyd E., Operating Engr., Munic. Water Works, 16 Wright St., Willoughby, Ohio (Oct. '47) *P*

Brown County Water Control & Improvement Dist. No. 1, Bradley Guthrie, Plant Supt., 113 E. Baker, Brownwood, Tex. (Corp. M. Jan. '48)

Columbia-Southern Chemical Corp., 414 Tower Petroleum Bldg., Dallas, Tex. (Assoc. M. July '38)

Cope, Ralph C., Water Assessment Supervisor, Water Div., Dept. of Public Utilities, 100 City Hall, St. Louis, Mo. (Apr. '46) *M*

Denton Water, Light & Sewer Dept., Henry G. Creel, Jr., City Engr., Denton, Tex. (Corp. M. Jan. '46)

(Continued on page 38)

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(*Continued from page 36*)

Doty, Dale M., Mgr., Culligan Soft Water Service, Box 157, Oxford, Ind. (July '50)

Erion, Ray, National Distillery, Box 71, Miamiville, Ohio (Apr. '39)

General Waterworks Corp., Box 1037, Pine Bluff, Ark. (Corp. M. July '46)

Helmers, E. Neil, Engr., Eng. Service Div., E. I. du Pont de Nemours & Co., Wilmington 98, Del. (Apr. '50)

Johnson, Donald L., Bacteriologist, Water, Gas & Sewage Disposal Dept., 414-16 W. 1st St., Duluth 2, Minn. (Apr. '48) *MPR*

Lyndes, Harry E., Local Mgr., General Chemical Div., Allied Chemical & Dye Corp., 1271 W. Bayard St., Denver, Colo. (Jan. '41)

Marek, Glenn E., Asst. Supt. & Purchasing Agent, Public Utilities, 310 N. Broadway, Rochester, Minn. (Jan. '45)

Mauch, T. C. M., Supt. of Pumping, Indianapolis Water Co., 113 Monument Circle, Indianapolis 6, Ind. (Dec. '24)

Millikin, William H., City Supt., Board of Water Comrs., City & County Bldg. Denver, Colo. (Apr. '40)

Parkhurst, Marvin L., Pres., Parkhurst Distributing Co., Traffic Circle, Routes 6 & 10, Ledgewood, N.J. (Oct. '44)

Patterson, James N., Chemist, Box 272, Salinas, Calif. (Oct. '35) *P*

Peterson, C. J., 8742 Sylmar Ave., Van Nuys, Calif. (July '46) *PR*

Porter, L. Clyde, Civil & Structural Engr., 1952—10th Ave. W., Seattle, Wash. (Apr. '46) *R*

Solvay Sales Div., Allied Chemical & Dye Corp., H. C. Todd, Mgr., Advertising & Sales Promotion, 40 Rector St., New York 6, N.Y. (Assoc. M. Jan. '36) *PR*

Spraker, W. F., 12017 Pacoima Court, North Hollywood, Calif. (Jan. '48) *M*

Studebaker Corp., The, J. M. Bowman, Supt. of Power Plants, 635 S. Main St., South Bend 27, Ind. (Corp. M. Jan. '51)

Teeple, Perry McKee, San Engr., State Board of Health, Box 210, Jacksonville, Fla. (July '50) *MR*

Wraight, Frank Donald, San. Engr., State Board of Health, 1700 N. Harrison St., Ft. Wayne, Ind. (Oct. '49) *P*

CHANGES IN ADDRESS

Changes received between January 5, and February 5, 1952

Adams, John M., The Baranof Hotel, Juneau, Alaska (Apr. '40) *MP*

Ambridge Water Authority, W. Wuycik, Secy., Box 329, Ambridge, Pa. (Corp. M. Jan. '41) *MP*

Amis, Buddy P., 2217 N. Pottenger, Shawnee, Okla. (Jan. '48)

Anderson, Felix A., Johnson & Anderson, 303 Community National Bank Bldg., Pontiac, Mich. (Apr. '50) *MP*

Appleyard, V. A., 5059 N. 26th Rd., Arlington, Va. (Jan. '49)

Arbuckle, Mortimer M., Chief Operator, Masterson, Tex., Box 150, Masterson, Tex. (Oct. '47) *P*

Armand, Antonio, 353 Calle 4, N. del Campo, Marianao, Havana, Cuba (Apr. '51) *PR*

Austin, Ralph D., 554 E. Monroe St., Little Falls, N.Y. (Apr. '38) *MPR*

Auburn Water Board, Mrs. Marie K. Straiton, Treas., Box 511, Auburn, Ala. (Corp. M. Jan. '49)

Bachelder, Herbert W., 714 W. German St., Herkimer, N.Y. (Oct. '40)

Baird, F. L., *see* Oakmont Municipal Authority

Bardwell, R. A., Engr. of Tests, Chicago & Eastern Illinois Ry., 1417 N. Gilbert, Danville, Ill. (Jan. '38) *P*

Baty, James Bernard, Prof., Civ. Eng. Dept., A & M College of Texas, College Station, Tex. (Apr. '37) *P*

Binford, Thomas A., Engr., The Dorr Co., Inc., 2705 Smith Tower, Seattle 4, Wash. (Oct. '45) *P*

Bird-Archer Co., The George Sill, Chief Chemist, 4337 N. American St., Philadelphia 40, Pa. (Assoc. M. July '29)

Bonham Water Dept., A. L. Skeen, Water Supt., City Hall, Bonham, Tex. (Corp. M. Jan. '44)

Bornemann, George F., Supt., Massapequa Water Dist., 84 Grand Ave., Massapequa, N.Y. (Apr. '38)

Bosch, Herbert M., Prof. of Public Health Eng., Univeristy of Minnesota, Minneapolis 14, Minn. (Sept. '29)

(*Continued on page 40*)

How Barrett* Waterworks Enamel Cuts Pipe-Protection Costs by the YEAR...by the MILE

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(*Continued from page 38*)

Bowelle, Bert, Box 432, Kennewick, Wash. (Jan. '48)

Brown, Horace A., Hotel Ottumwa, Ottumwa, Iowa (June '11)

Browne, Floyd G., Cons. Engr., 123 W. Church St., Marion, Ohio (June '26) *MP*

Brownhill, Harold E., 3081 Stanley Ave., Niagara Falls, Ont. (Jan. '51)

Bubbis, Nathan S., Gen. Mgr., Greater Winnipeg Water & San. Dist., 455 Ellice Ave., Winnipeg, Man. (Jan. '45) *MPR*

Burley, Fred H., Engr., Tests & Inspection, Dept. of Water Supply, 12772 Ilene, Detroit 4, Mich. (July '46) *R*

Carle Place Board of Water Comrs., Edward Dolegoski, Supt., Water Dist., 453 Westbury Ave., Carle Place, N.Y. (Mun. Sv. Sub. July '49) *M*

Carmichael, George T., 475 Williaman St., Jackson, Miss. (Oct. '49)

Caruthers, Dale E., 11015 Mayfield, Rosedale Gardens, Plymouth, Mich. (Oct. '50)

Case, W. D., Owner, Case Eng. Co., 4144 Lindell Blvd., St. Louis 8, Mo. (July '42) *P*

Chenery, Christopher T., Chairman of the Board, Southern Natural Gas Co., 90 Broad St., New York 4, N.Y. (June '26)

Churchill, M. A., 4026 Ridgcroft Rd., Baltimore 6, Md. (Jan. '49)

Colton, Grant A., *see* Golden Anderson Valve Specialty Co.

Cowden, Burney B., Box 145, Eagle Lake, Fla. (Jan. '48)

Culp, Russell L., Chief, Water Supply Section, State Board of Health, Marvin Hall, University of Kansas, Lawrence, Kan. (July '48)

Dandridge, E. F., Asst. Controller & Chief Accountant, Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '34)

Dauphin, Town of, E. Lundman, Town Engr., Dauphin, Man. (Corp. M. Jan. '47) *MP*

Davis, H. M., Chemist, Research Div., Canadian Breweries, 307 Fleet St., E., Toronto, Ont. (Jan. '47) *PR*

Davy Engineering Co., Philip S. Davy, Chief Engr., 524 Main St., La Crosse, Wis. (Corp. M. Jan. '48)

Davy, Philip S., *see* Davy Engineering Co.

De Boise, Joseph, Supt., Water Dept., 68 Central Ave., Lodi, N.J. (July '43) *M*

Dodd, C. K. S., Cons. Engr., 625 E. 18th St., Sarasota, Fla. (Jan. '36)

Doepken, Robert D., Sales Engr., 4368 Bel Air Dr., La Canada, Calif. (Oct. '50)

Dolegoski, Edward, *see* Carle Place (N.Y.) Board of Water Comrs.

Duckworth, Leon S., Supt. of Filtration, Bureau of Water, 1501 Pleasure Rd., Lancaster, Pa. (Jan. '37) *MP*

Fuller, A. S., Cons. Civ. Engr., 4655 Vance, Wheatridge, Colo. (July '48) *R*

Fynsk, Arthur, 1314 Kynlyn Dr., Kynlyn Apartments, Wilmington, Del. (Jr. M. Oct. '50)

Garrett, Melrose T., Jr., Vice-Pres., Garrett Eng. Co., 5008 Almeda St., Houston 4, Tex. (Jan. '51)

Glisson, J. Floyd, *see* Titusville (Fla.) Water Dept.

Golden Anderson Valve Specialty Co., Grant A. Colton, Pres., 207 Keenan Bldg., Pittsburgh 22, Pa. (Assoc. M. Oct. '34)

Goode, Norman John, 2199 Lafayette St., Victoria, B.C. (Jan. '47)

Graham, Ralph E., 1444 W. Garvey Ave., Covina, Calif. (Oct. '49) *MR*

Halpin, David J., 2016 Scottwood, Toledo, Ohio (Oct. '50)

Hammond, J. Curtis, Chief Engr., Water Works Board, Box 271, Gadsden, Ala. (Oct. '44)

Hannan, J., Jr., Chief Engr., Intercounty Constr. Corp., 4720 Baltimore Ave. Hyattsville, Md. (June '30)

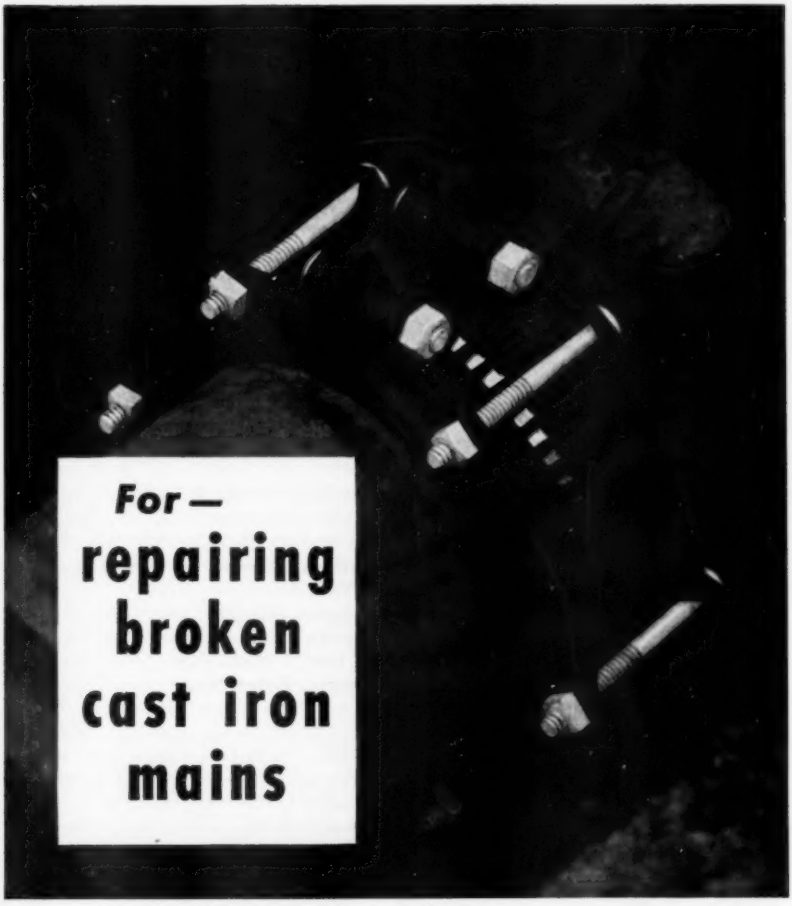
Harper, M. J., Eastern Regional Mgr. of Sales, Rockwell Manufacturing Co., 7701 Empire State Bldg., New York 1, N.Y. (Jan. '49)

Hartley, John R., Vice-Pres., Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. (Apr. '43) *MPR*

Hendricks, Gerald F., San. Engr., 1402 Lawton Ave., Columbus, Ind. (Jan. '46) *P*

Henry, L. A., Cons. Engr., 409 Pyramid Bldg., Little Rock, Ark. (Oct. '45) *R*

(*Continued on page 42*)



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Hinds, Julian, Gen. Mgr. & Chief Engr., United Water Conservation Dist., 806 Railroad Ave., Santa Paula, Calif. (May '31) *MPR*

Hobson, J. R. A., Jr., Chief, Mech. Dept., Knappen-Tippetts-Abbett-McCarthy, 62 W. 47th St., New York 36, N.Y. (Jan. '48) *MR*

Holland Board of Public Works, G. H. Rendleman, Supt., City Hall, Holland, Mich. (Corp. M. Jan. '46)

Hudson, LeVerne D., 317—4th St., Ann Arbor, Mich. (Oct. '41) *P*

Ithaca Dept. of Public Works, C. W. Rich, Asst. to Supt., Water & Sewer Div., City Hall, Ithaca, N.Y. (Mun. Sv. Sub. Jan. '49) *MP*

Keith, H. L., Water Treatment Dept., Layne-Northern Co., Inc., 401 S. DeLorenzi Ave., Mishawaka, Ind. (Oct. '50)

Kellogg, Glen T., Asst. Director, Water Pollution Control Com., State Board of Health, Little Rock, Ark. (July '49)

Kerr, S. Logan, S. Logan Kerr & Co., Inc., 1518 Bethlehem Pike, Flourtown, Pa. (Jan. '35) *M*

Keysor, John W., Engr., State Div. of Water Resources, 2354 Hernando Rd., Sacramento 21, Calif. (Oct. '50)

King, Ralph N., *see* Thompson, R. M., Co.

Kingsbury, William Carter, Asst. Engr., Water Dept., Manhattan Beach, Calif. (July '49)

Kline, J. D., Chief Engr., Public Service Com., 162 Lady Hammond Rd., Halifax, N.S. (Jan. '45) *M*

Lardieri, Nicholas John, 126 Oraton, East Orange, N.J. (Jr. M. July '49)

Lawrence Water Dept., J. H. Wigglesworth, City Hall, Lawrence, Kan. (Corp. M. Feb. '27)

Lee, Lester D., Pres., Hitchcock & Estabrook, 300 Lincoln Bldg., Minneapolis, Minn. (Apr. '44) *MPR*

Lemler, S. F., *see* Riviera Utilities Water Dept.

Liddle, Elmo G., 18925 Grand River Ave., Detroit 23, Mich. (Apr. '43) *P*

Liedholz, G. W., Div. Mgr., National Aluminate Corp. (Chicago) 1315 Fountain St., Ann Arbor, Mich. (Oct. '45)

Loken, Ralph, *see* New Mexico Public Service Co.

Ludwig, Russell G., San. Engr., Ludwig Bros., Engrs., 1416 Camelia Dr., Alhambra, Calif. (July '49) *P*

Lundman, E., *see* Dauphin (Man.)

Macnab, Ira P., Gen. Mgr., Public Service Com. 162 Lady Hammond Rd., Halifax, N.S. (July '43) *PR*

MacPherson, William, The Palms, St. George, S.C. (July '49) *MP*

McArthur, Charles E., Pres. & Director, Kansas City Suburban Water Co., 828 Dwight Bldg., Kansas City, Mo. (Apr. '47)

McCarthy, Gerald T., Knappen-Tippetts-Abbett-McCarthy, 62 W. 47th St., New York 36, N.Y. (Apr. '42) *PR*

McDade, Thomas, *see* Park Forest (Ill.) Water Co.

McEntee, Harry E., Asst. Supt., Water & Sewer Dept., 222 Riverside Dr., Mt. Clemens, Mich. (July '38)

Meeker, Robert H., East St. Louis & Interurban Water Co., 23 N. Illinois St., Belleville, Ill. (July '45) *MPR*

Mejias, Manuel Fernando, Sta. Rosa a Puente Canaos, Qua. Chapultepec, Caracas, Venezuela (Jan. '49)

Miles, Harry B., 45 Grant St., Utica, N.Y. (June '24) *M*

Milford Water Co., Robert Symonds, Supt., 226 Main St., Milford, Mass. (Corp. M. July '35) *M*

Miller, Burton Rich, Engr., 1625 New Jersey Ave., Apartment 1, New Castle, Del. (Oct. '50)

Morehouse, Wallace W., Cons. Engr., 21 E. Norman Ave., Dayton 5, Ohio (Jan. '23) *Director '38–'39, '42–'45. Fuller Award '50. MR*

Morris, Ronald W., Plant Supt., The Anthes-Imperial Co., Ltd., Winnipeg, Man. (July '48)

Murray, Joseph Francis, Prin. Asst. Engr., Div. of Water, 101 City Hall Annex, Newark 2, N.J. (Jan. '42) *MPR*

Ness, Robert Olaf, 3101 Central Ave., Minneapolis 13, Minn. (Oct. '48)

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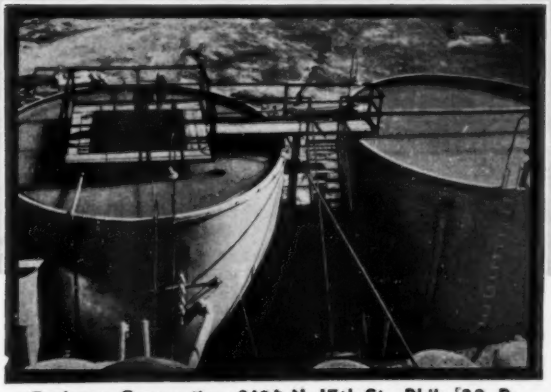

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New Mexico Public Service Co., Ralph Loken, Div. Mgr., Santa Fe, N.M. (Corp. M. Mar. '24)

Noel, Carl F., Dist. Mgr., A. P. Smith Mfg. Co., 920 Grayson St., Berkeley, Calif. (July '43) *PR*

Oakmont Municipal Authority, F. L. Baird, Mgr., 748 Allegheny River Blvd., Verona, Pa. (Corp. M. Apr. '09) *M*

Oberholtz, Lester, 2500 W. 6th St., Los Angeles 5, Calif. (Jan. '41)

Oeffler, Weldon A., Plant & System Gen. Mgr., North Miami Beach Water Board, Box 36, North Miami Beach, Fla. (Jan. '37) *M*

Ogden, William H., Morris Ave., Glen Cove, N.Y. (July '35)

Palmer, F. C., Chief Accountant, Public Service Com., Box 574, Halifax, N.S. (Jan. '46) *M*

Pardoe, William S., 701 Beacom Lane, Merion Station, Pa. (Apr. '44)

Park Forest Water Co., Thomas McDade, 2 Plaza, Park Forest, Ill. (Corp. M. July '50)

Parsons, Richard C., Institute of Inter-American Affairs, Div. of Health & San., Apdo. 1723, Caracas, Venezuela (Oct. '47)

Paterson, A. B., Chairman of the Board, New Orleans Public Service, Inc., 317 Baronne St., New Orleans 9, La. (July '37)

Patterson, J. R., Floyd G. Browne & Assocs., 123 W. Church St., Marion, Ohio (Jan. '45)

Paulette, George W., Dist. Engr., Infilco, Inc., Drawer A, Altamonte Springs, Fla. (Oct. '46)

Perry, G. C., Mgr., Crane Co., 321 E. 3rd St., Los Angeles 54, Calif. (Jan. '41)

Peterson, Thoburn F., 803½ Brighton Blvd., Zanesville, Ohio (Jan. '50)

Pitkin, William V., Asst. Secy. & Treas., Ulrich Chemical Co., 31 E. Georgia, Indianapolis, Ind. (Oct. '49) *MPR*

Rader, Earle M., 8701 N.E. 10th Ave., Miami, Fla. (Oct. '50)

Ragan, Richard Walton, Engr., State Board of Health, 9848 Elaine Rd., Jacksonville 7, Fla. (Oct. '51)

Rasmusson, Marvin H., *see* Standard Brands, Inc.

Rendleman, G. H., *see* Holland (Mich.) Board of Public Works.

Renner, Lyall G., Operating Engr., Public Service Com., 162 Lady Hammond Rd., Halifax, N.S. (Jan. '47) *M*

Revell, Rufus B., Florida Public Utilities Co., Marianna, Fla. (Oct. '49) *MP*

Rich, C. W., *see* Ithaca (N.Y.) Dept. of Public Works

Riviera Utilities Water Dept., S. F. Lemler, Gen. Mgr., Foley, Ala. (Corp. M. July '48) *M*

Rothman, Edwin, Div. Mgr., Wallace & Tiernan Co., Inc. 5940 Main St., Trumbull, Conn. (July '35) *P*

Rowe, Edmund L., c/o Post Engrs., APO 949, c/o Postmaster, Seattle, Wash. (Jan. '48)

Runyan, Damon O., Cons. Engr., 8592 W. Colfax, Denver, Colo. (Oct. '47) *MPR*

Schneller, M. P., 1144 Dearborn Ave., Aurora, Ill. (July '47)

Sill, George, *see* Bird-Archer Co.

Skeen, A. L., *see* Bonham (Tex.) Water Dept.

Smith, S. Morgan, Co., Carl J. Wilcox, Mgr., Valve Div., York, Pa. (Assoc. M. Mar. '34)

Snow, Barton S., Pres. & Hydr. Engr., T. W. Snow Constr. Co., 10 W. Wilson St., Batavia, Ill. (June '30) *P*

Snyder, C. L., Snyder, McLellan, Rhoads & Watson, Engrs., Hillsboro, Ind. (Apr. '49)

Snyder, Kenneth T., Gen. Mgr., Western Div., Atlas Mineral Products Co., Box 252, Houston 1, Tex. (Jan. '50)

Sopp, George C., Asst. Mgr., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Apr. '36) *Fuller Award '45. M*

Spieker, Roy G., Greeley & Hansen, Cons. Engrs., 220 S. State St., Chicago 4, Ill. (Jan. '47) *P*

Standard Brands, Inc., Marvin H. Rasmusson, Process Supt., Peekskill Mfg. Branch, Peekskill, N.Y. (Corp. M. Apr. '47) *P*

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Stockman, Robert L., Dist. Engr., State Dept. of Health, 4400 Sunnybrae Dr., Yarrow Pt., Bellevue, Wash. (Oct. '47) *MP*

Straiton, Marie K. (Mrs.) *see* Auburn (Ala.) Water Board

Strock, B. F. (Mrs.), 661 Pueblo St., W., Reno, Nev. (Jan. '47) *M*

Stuart, Charles L., Mgr., Central Div., Southern California Water Co., 10426 S. Normandie Ave., Los Angeles 44, Calif. (Jan. '40) *M*

Stuppy, Mark L., F. B. Leopold Co., Inc., 2413 W. Carson St., Pittsburgh 4, Pa. (Apr. '49)

Symonds, Robert, *see* Milford (Mass.) Water Co.

Thompson, R. M., Co., Ralph N. King, 712 Grand Central Ave., Clearwater, Fla. (Corp. M. Apr. '48) *P*

Titusville Water Dept., J. Floyd Glisson, City Mgr., City Hall, Titusville, Fla. (Mun. Sv. Sub. Apr. '51) *MPR*

Van Reenen, W. J., Vice-Pres., in Charge of Sales, American Norit Co., Inc., 6301 Glidden Way, Jacksonville 8, Fla. (Jan. '39) *P*

Van Zandt, W. K., Asst. Director, Utilities Dept., City Hall, Houston, Tex. (Apr. '42) *M*

Vokoun, Harold J., San. Engr., Box 4-M, RFD 3, Vienna, Va. (July '49)

Werner, Gustave G., Jr., Orinoco Mining Co., Apdo. 3, Bolivar, Venezuela (Jan. '46)

Wertz, Emerson D., Cons. Engr., E. D. Wertz & Assocs., Box 306, Bryan, Ohio (Jan. '47) *MPR*

Westcott, Ralph M., Cons. Engr., 5315 Linda Vista Dr., La Canada, Calif. (Apr. '50)

Wigglesworth, J. H., *see* Lawrence (Kan.) Water Dept.

Wilcox, Carl J., *see* Smith, S. Morgan, Co.

Wuycik, W., *see* Ambridge (Pa.) Water Authority

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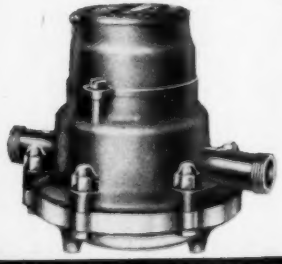

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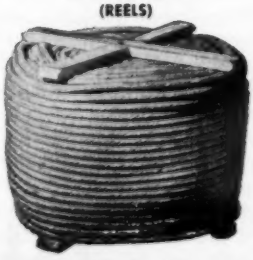

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

DISINFECTION

A Study of the Chloro Derivatives of Ammonia and Related Compounds, With Special Reference to Their Formation in the Chlorination of Natural and Polluted Waters. A. T. PALIN. Wtr. & Wtr. Eng. (Br.), **54**:151, 189, 248 (Oct., Nov., Dec. '50). Paper presented to Public Works and Municipal Services Congress Nov. 16, '50, under auspices of British Waterworks Assn., and published with author's permission. Paper awarded first prize in open competition organized by congress council. Many great advances in water treatment associated with use of chlorine. In treatment of water by chloramine process, chlorine substituents of ammonia deliberatedly produced by combined application of ammonia and chlorine. After 1919, Houston found that the more chlorine used the more certain would be absence of tastes after dechlorination. Faber noted in 1939 that sometimes, as rate of chlorine application was increased, chlorine residual behaved erratically. Min. point of curve was called breakpoint. Phenomenon probably connected with formation and subsequent decompn. of chloramines and similar chlorocompds. Faber ('47) suggested that compn. of residual chlorine provides most suitable criterion for classifying chlorination process. When chlorine and ammonia react together in water to form chloramines, some indication of nature of products would be afforded by reliable ests. of relative amts. of uncombined ammonia and of ammonia used up in forming chloramines. Gattermann (1888) concluded that chlorination proceeded in three stages:

$NH_3 + Cl_2 \rightarrow$
NH_2Cl (monochloramine) + HCl.
$NH_2Cl + Cl_2 \rightarrow$
$NHCl_2$ (dichloramine) + HCl.
$NHCl_2 + Cl_2 \rightarrow$
NCl_3 (nitrogen trichloride) + HCl.

Dichloramine has not been isolated and is known only in soln. NCl_3 isolated by Dulong in 1811. Presence in water of other substances capable of reacting with chlorine affect breakpoint but, in chlorine-ammonia reactions, in Branch 1 of typical curve, chlorine is present in combination with ammonia as chloramine. Reactions, however, do not quite follow simple paths represented. Phenomena associated with breakpoint-process chlorination still await explanation. More evidence against than for simple theory of oxidation to nitrogen. Although nitrogen may be main product when excess of chlorine is used, smaller amts. of other compds. may be produced. Ammonia is destroyed at breakpoint, but Griffin and Chamberlin ('41) showed that ammonia reappears after this point in amts. to 0.1 ppm. Fair and his coworkers concluded that formation of chloramines is stepwise, thus:

$$NH_3 + HOCl \rightarrow NH_2Cl + H_2O$$
$$NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$$
$$NHCl_2 + HOCl \rightarrow NCl_3 + H_2O$$

Conclusion identical with that of Gattermann. Value of 6.7×10^5 was found

(*Continued on page 50*)

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(*Continued from page 48*)

for equil. constant where:

$$K_{equil.} = \frac{(NH_3)\ (NHCl_2)}{(H^+)\ \ (NH_2Cl)^2}$$

Attempt was made to calculate, from this const., relative concns. of $NHCl_2$ and NH_2Cl at various pH values. Fair and his associates state that virtually none of fundamental chemistry of breakpoint reactions is known and even their products are uncertain. Holwerda ('30) concluded that available chlorine and ammonia should disappear in ratio of 7.6:1 by wt., this ratio being theoretical one for oxidation of ammonia to nitrogen. Observations in Expt. 1 provided further evidence to support conclusions previously reached on interpretation of ammonia-test results. Final confirmation came in Expt. 3, in which it was evident initial ratio of chlorine to ammonia had greatly affected nature of compds. produced and their subsequent decompn. Effect of Cl:N ratio further demonstrated in Expt. 4, in which, for initial Cl:N ratios below 5:1, reactions led almost entirely to formation of NH_2Cl with no more than traces of $NHCl_2$. As initial Cl:N ratio rises from 5:1 to 10:1, increased quants. of $NHCl_2$ are formed, and NCl_3 also appears with some excess of free chlorine. In addition to initial Cl:N ratio, pH greatly affects chlorine-ammonia reactions. Chlorine-ammonia reactions explored for wide pH range and with various initial Cl:N ratios (by wt.). With increased proportions of NCl_3 and $NHCl_2$, and excess Cl_2, reactions leading to decompn. of chlorocompds. cause decided total available chlorine loss. Effects very pronounced and lead, after one day's contact, to practically complete disappearance of NH_2Cl and $NHCl_2$. Available residual chlorine in form of NCl_3 with some free Cl_2. At less than pH 4, NCl_3 is in excess. Between pH 4 and

(*Continued on page 54*)

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Leading waterworks engineers estimate the useful life of cast iron pipe at *4 to 5 times* the average term of a water revenue bond issue. They base their estimates on the fact that over 35 American cities have cast iron mains in service that were installed more than 100 years ago. Moreover, a survey sponsored by three waterworks associations shows that 96% of all six-inch and larger cast iron pipe *ever laid* in 25 typical cities, are still in service. Thus, the *strength factors* of long life, native to cast iron pipe, are self-evident.

When you consider that over 95% of America's water distribution systems are constructed with long-lived cast iron pipe, can you doubt that it is *America's No. 1 Tax Saver?*

America's oldest functioning water main is in its 135th year of service in Philadelphia's distribution system. Cast iron, of course. Over 30 other cities have century-old cast iron mains in service.

CAST IRON

CAST IRON PIPE

America's No. 1 Tax Saver

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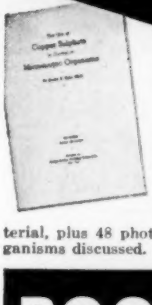
FREE

to WATER WORKS and SEWAGE MEN

HOW TO CONTROL ALGAE



"The use of Copper Sulphate in Control of Microscopic Organisms" is an authoritative work on control of micro-organisms and elimination of tastes and odors. Describes methods of controlling various forms of microscopic life commonly encountered in water supply systems. Contains descriptive material, plus 48 photo-micrograph studies of organisms discussed.

ROOT AND FUNGUS CONTROL

"Copper Sulphate for Root and Fungus Control in Sanitary Sewers and Storm Drains," by John W. Hood, contains information published for the first time. This material includes actual methods for control and operating procedure. Here's the book that is a "must" for all sewage men.

GET EITHER OR BOTH OF THESE BOOKLETS ABSOLUTELY FREE—

These two valuable booklets, so important to all water works and sewage men, are yours *without obligation*. For your copy of either one or both books, write on your company letterhead to Dept. JW-352.

PHELPS DODGE REFINING CORPORATION

40 Wall Street New York 5, N. Y.

(*Continued from page 50*)

7, relative proportions of NCl_3 and Cl_2 remain fairly steady with Cl_2 in excess. At more than pH 7, proportion existing as NCl_3 gradually reduces until more than pH 8, at which residual is entirely in form of free Cl_2. Breakpoint effect is most marked within pH range 6–9. Between 7 and 8, decompn. reactions may proceed to such extent that, by suitable choice of initial Cl : N ratio, available residual chlorine may disappear after one day. Departure from this optimum ratio, either above or below it, leaves gradually increasing amts. available chlorine residuals. Following suggestions based on results of author's expts.:

$$NH_4 + HOCl \rightarrow NH_2Cl + H_2O + H$$
$$NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$$
$$NHCl_2 + HOCl \rightarrow NCl_3 + H_2O.$$

Monochloramine is decomposed by excess chlorine:

$$2NH_2Cl + HO_2Cl \rightarrow N_2 + 3HCl + H_2O$$

so that, in water having pH value of 8 or more, although excess chlorine and monochloramine may coexist for time, chloramine is gradually lost and will disappear if initial chlorine excess is sufficient. Systems contg. both mono- and dichloramine are unstable and there is fairly rapid decompn. with eventual disappearance of one or other form. In absence of chloramines, solns. contg. both free chlorine and nitrogen trichloride are comparatively stable. If final oxidation product of ammonia is nitrogen. Available chlorine and ammonia-nitrogen should disappear in ratio of 7.6 : 1. In std. nitrite test, sulphanilic acid is first added to water and followed by alpha-naphthylamine acetate. In presence of nitrites, red colors appear. Satisfactory detn. of nitrites not obtained when large quants. of chlorine are added to water in treatment process. Under these conditions, alpha-naphthylamine acetate should be added first, and then sulpha-

(*Continued on page 56*)

Cutting Valve Costs for a lifetime

This interesting assembly consists of a 20 inch Rensselaer valve with reducing and increasing sections for installation in a 30 inch pipe line. The integral type gear case is designed for the working pressure of the valve and is packed with oil for lifetime service.

There is no need for a concrete vault for valves equipped with integral type gear cases. Just install valve boxes, shovel back the dirt and forget it, for this is the Rensselaer double disc valve with the well known wedge action. On closing, when the gates reach a position opposite their seats, the powerful wedging action presses them squarely and firmly against their seats. It is impossible to damage the stem threads or throw the stem out of alignment, and the gates open and close easily.

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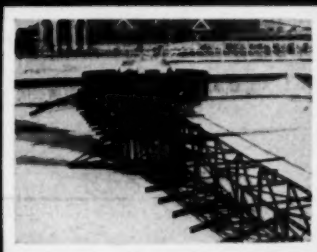
102

ELECTRO RUST-PROOFING AT WORK!



At a midwestern city, ERP cathodic protection systems have been controlling corrosion in large diameter clarifiers for several years. A recent inspection showed that "about 95% of the red lead undercoat was intact and—no pitting was taking place even at weld seams and bolt and rivet heads." Following this inspection, a neighboring city ordered ERP systems for both its clarifiers and flocculators.

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BELLEVILLE 9, NEW JERSEY

CATHODIC PROTECTION FOR ALL BURIED AND SUBMERGED STRUCTURES

(Continued from page 54)

nilic acid. Effect of NCl_3 on nitrite test is shown further in Expts. 16 and 17, in which ammonia-nitrogen was added to water contg. excess chlorine. Unreacted free ammonia not present after reaction period. Apparent nitrite reading obtained in both expts. when nitrite reagents were added in usual order. Magnitude of false readings was directly related to concn. of NCl_3 in samples. Presence of 1 ppm NCl_3 in water will apparently produce false reading in nitrite test equiv. to 0.0006 ppm of nitrite-nitrogen. Except for chloro derivatives, nitrate is probably sole product in addition to nitrogen, and amts. obtained by anal. are adequate to acct. for observed divergence from 7.6 : 1 ratio. Although nitrogen is main oxidation product from addition of excess chlorine to water contg. low concns. of ammonium salts, side reactions occur. In chloramine treatment by application of both chlorine and ammonia, ratio of doses is chosen to form and stabilize chloramines by ammonia excess. For all pH values of more than 7, product obtained is monochloramine with no more than traces of dichloramine. At less than pH 7, proportion of dichloramine increases gradually until, at pH 5, two chloramines are present in approx. equal proportions. Final disappearance of monochloramine occurs at approx. pH 4 and is accompanied by appearance of small amts. of nitrogen trichloride. If amt. of chlorine remaining in treated drinking water must be reduced before distr., reduction should be possible by controlled application of ammonia, to leave free chlorine residual or a combined chlorine residual, or to effect almost complete dechlorination. Application of anal. methods developed in this work should reveal new lines of research. Compn. of nitrogenous org. matter in natural and pold. water is mainly proteins and protein degradation products. Such compds. generally contain NH_2 and

(Continued on page 58)

IS *YOUR* WATER-SOFTENING SYSTEM SLUGGISH?

It is, unless your exchanger

. . . Has capacity up to 30,000 grains of hardness per cubic foot, even at peak flow rates of 10 gal./sq. ft./min.

. . . Thrives on a salt-starvation diet of as little as ¼ pound per 1,000 grains of hardness removed.

. . . Gives years of trouble-free service without attrition losses—can be operated safely over the entire pH range and at high temperatures —is stable to silica, acid, alkali, and oxidizing and reducing agents.

AMBERLITE IR-120 Resin Exchange meets all these efficiency tests. A typical AMBERLITE unit has delivered almost 5,000,000 gallons of softened water per cubic foot of resin without capacity or attrition losses; and it's still in operation.

Ask your water-treating equipment supplier or your consulting engineer about AMBERLITE IR-120 — as the exchanger in a new softening installation, or as a replacement for siliceous exchanger. Meanwhile, write Dept. W-1 for full technical data.

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(Continued from page 56)

NH groups, and application of chlorine may result in formation of complex chloramines and similar substitution products. These possible reactions with chlorine may cause amino acids and proteins to affect greatly results of chlorination. Expts. indicate that, whatever final products of action of chlorine on amono acids in water, initial reactions result in formation of monochloramino derivatives with little dichloroamino derivatives. Of amino acids studied, stability of chlorocompds., as formed in initial reactions, is greatest for aminoacetic acid, and decreases in the order: valine, alanine, tyrosine, leucine, cystine. Reactions in chlorination of cystine generally too complex to permit adequate interpretation by data from expts. Typical curve usually obtained where, for fixed chlorine dose, available residual chlorine, after contact period, is plotted against increasing amino acid or protein dose. Curves characterized by initial fall and secondary rise. Extent of rise depends on stability of chloramino derivatives. Impurities most likely to affect results of chlorination processes are ammonia nitrogen, albuminoid nitrogen, and absorbed oxygen. Waters contg. mineral salts but devoid of org. impurity do not absorb much chlorine, and dose-residual curve will show general rise in residual-chlorine concn. with increasing chlorine dosages. Waters derived from upland watersheds usually contain little or no ammonia nitrogen and only little albuminoid nitrogen, but contain much absorbed oxygen due to presence of essentially carbonaceous org. matter. Results of chlorinating waters must generally be related to contact time available at treatment works. Possible NCl_3 production in waters treated by breakpoint chlorination and fact that NCl_3 formation can be serious hindrance to these processes recognized in U.S. Although dechlorination is obvious method of destroying NCl_3, disadvantage is fact that it does not permit sending out chlorine residual in distributed water. Except for odor nuisance, NCl_3 formation is of some importance because of reports that flour treated by NCl_3 (agene) produces hysteria when fed to dogs. Toxicity not due to NCl_3 but to some toxic agent produced by action of NCl_3 on gluten. Concns. of residual chlorine normally encountered in Great Britain are so minute that they will probably produce no ill effects on British consumers.—*H. E. Babbitt.*

HYDROLOGY, CONSERVATION, AND IRRIGATION

Studies on Ground Water. C. H. Pope. Jul. Gjellerups Forlag, Copenhagen, Denmark, 114 pp. Studies on the compn. of ground water in Copenhagen showed the geological forma-

(Continued on page 60)

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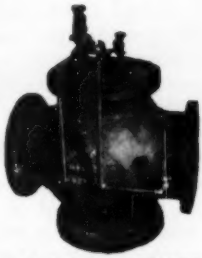
ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge



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Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

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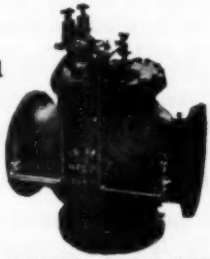
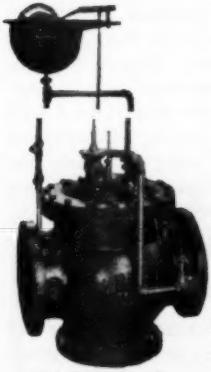


COMBINATION VALVE

Combination automatic control both directions through the valve.

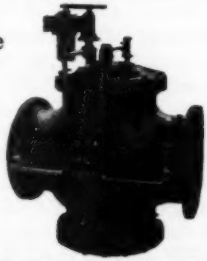


FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

(Continued from page 58)

tions capable of Na zeolite activities and the presence of anaerobic bacteria overlapping the lenses of sand-contg. water, whereas, in other areas with high water tables, underlying material is peaty. In ion-exchange area, water has considerable temporary and permanent hardness. Adjacent to this zone, the water originating in the peaty soil, contains considerable H_2S and CH_4. The H_2S, ammonia, occurs most frequently in water contg. sulfates, free CO_2, or bicarbonates. Studies on treatment of CH_4-contg. water show that gas is produced by the anaerobic bacteria, Methanomonas, which develop rapidly, and, if the water is properly aerated, the development of the organisms is stopped. Special type of aerated filter removes the CH_4, H_2S, and CO_2. New method to det. anaerobic organisms in ground water described, together with modified methods of H_2S and CH_4 detns.—*W. Rudolfs.*

Filtering Power of Soils Along the St. Martory Irrigation Canal, Thirion. L'Eau (Fr.), **38**:145 (Sept. '51). The improved Muntz method used here to det. best irrig. practices for an agricultural region of southwest France (17,300 acres). Soils examd. had sandstone (Molasse) substratum, with a topsoil layer of either podzolized silt, or more recent clays contg. pebbles; both (top) soils contain 25–50% fine sand; a silt plus fine sand content of approx. 79% for the first soil, 69% for the second. Podzolized soils had filtering powers(in Muntz units) of 6 for cultivated areas, 8 for meadows, indicating little filtration, whereas clays had corresponding values of 9 and 11 (medium filtering power). Horizon sections in podzols showed values of up to 20 in clays of up to 40, possible evidence of short-circuiting with the water table (only 15–21 ft deep in spots), which would favor soil impoverishment by leaching out of salts and finely divided constituents into the substratum. A more rational irrig. of the podzolized soils by frequent application of small quants. of water, to avoid pooling, is recommended. Crops benefiting most from irrig. in dry weather are corn and meadow grass.—*M. Albanese.*

Recovery of Atmospheric Humidity. P. Descroix, L'Eau (Fr.), **38**:127 (Aug. '51). Feasibility of such recovery on a practical basis was studied through calcns. made on some 13 crushed-limestone pyramids (2-in. stone; $95 \times 80 \times 10$ ft high) (2,750 cu yd) built on a Crimean mountain ridge, and having supposedly provided (according to Zibold, 1905) up to 6.34 gpd per cu yd stone (14,400 gpd each) to the city of Theodosia in ancient times. Theoretical studies show possible water yield from condensed humidity of only 0.26 gpd per cu yd (with air at 25 C. 90% humidity), but this amt. could be as much as 11.78 gpd per cu yd by recovering 60 in. of rain per yr. Practical expts. include to date: pyramids of pebbles of the same dimensions as the old pyramids and an atmospheric well, or ventilated-brick structure, with slates acting as condensers inside (Kuapen, France, 1931); a small pyramid of crushed limestone (14.85 cu yd Bel Air Experiments Station, France, 1929). The first two attempts failed completely, whereas the last yielded only 0.008 gpd per cu yd. Conclusions suggest pyramids were just rain- and cloud-water collectors, and urge new studies to be made on spot.—*M. Albanese.*

FILTRATION

Poaka Beck Filtration Plant of the Barrow-in-Furness Corporation. Anon. Wtr. & Wtr. Eng. (Br.) **55**: 237 (July '51). Two main sources of water supply for Barrow-in-Furness

(Continued on page 62)

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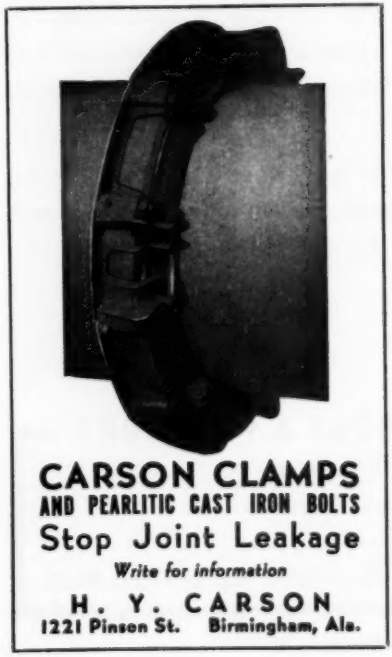
95 Years of Continuous Service

(Continued from page 60)

are impounding reservoirs: Harlock, Pennington, and Poaka Beck; and R. Duddon. Initially, each source to be called on for 4 mgd (Imp.) but eventually decided only to consider Poaka Beck Res. to supply increases. Suitable site for treatment plant for water from all reservoirs was available below Poaka Beck Res. where 4-mgd (Imp.) plant was decided upon. Plant consists of main filter house and mchy. room with workshop, office, lab., chem. house and store. Chems. stored on upper floor of chem. house. Elec. provided by two water-turbine-driven generating sets. Turbo generators, wash-water pumps, and air blowers, together with their switchboards, are located at ground floor level in main hall of bldg. Incoming raw water passed through water turbine suitable for operating under any head from 75 to 100 ft. There are 4 air-scoured, rapid, gravity filters, with combined capac. of 4 mgd at rate of 83 gph (Imp.) per sq ft. Each filter equipped with module automatic flow controller. Each control cabinet on upper operating platform carries strip-chart recorder for filtering head loss and filter flow, module-setting dial, selector levers for hydraulically operated valves, push buttons for control of pressure fluid to these valves, signal lights, hydraulic pressure gages, and push buttons for remote control of air-scour blowers. Air obtained from one of two direct-coupled, elec.-driven, rotary blowers. Wash water obtained from high-level storage tank. Four 600-gal (Imp.) concrete soln.-storage tanks are provided, two for alumina and two for alkali. Lime-mixing tank provided. Alumina, alkali, and lime automatically proportioned to raw-water flow over range of 8:1. Final sterilization by chlorine gas, with automatic changeover from exhausted to standby cylinders. Lab. equipped with all app. necessary for routine control. Plant producing first-class water free from turbidity and having low final color with filter runs of 30 to 48 hr. Considerable reduction in filter runs at certain seasons. Condition traced to presence of many siliceous diatoms. Since application of copper sulfate to reservoirs, is possible to maintain normal filter runs.—*H. E. Babbitt.*



A Model Filtration Plant for a Problem Town. J. L. MORRISON. Pub. Wks., **81**:11:38 ('50). New water works of Chapel Hill, N.C., designed to provide 3 mgd of water to a pop. of 15,000 with an addl. fluctuating pop. of 7,000. Water drawn from University Lake, which has a capacity of 600 mil gal; treatment consists of addn. of alum, lime, and carbon, flocculation, sedimentation, and filtration.

(Continued on page 64)

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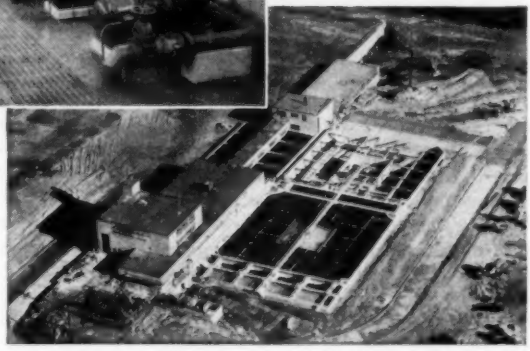

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(Continued from page 62)

Provision made for future expansion of the plant to yield 6 mgd, which is the estd. safe yield of drainage area. —*W.P.A.*

Experiments in Primary Filtration of Severn Water and Extensions to Worcester Water Works. H. A. MACKRILL. J. Inst. Wtr. Engrs. (Br.), **4**:361 ('50). Water supplies for Worcester are derived from R. Severn and are treated by sedimentation and filtration through slow sand filters. The water is chlorinated before distr. The high content of suspended matter in the raw water necessitated frequent cleaning of the filters, and, because of increased pop., extensions to the works became necessary. As it was thought primary filtration would be best method of reducing load on slow filters, a small rapid gravity filter with coarse medium was constructed. Chem. and bact. anals. were made of influent and effluent of primary filter. These anals. were compared with results obtained from a slow sand filter of comparable size filtering settled water. With optimum rate of filtration through the primary filter of 100 gph per sq ft, filtration rate through the slow sand filter could be increased from 4 to 8 in. per hr, and the bact. qual. of the final effluent was improved. Primary filtration alone reduced the numbers of bacteria to approx. one-tenth of those in settled water. Results of the bact. anals. given in graphs. As a result of these expts., new extensions to the works will include six primary rapid filters, each with an effective area of 420 sq ft. A new intake on the river bank and a sedimentation tank with a capac. of approx. 5 mil gal will also be constructed.—*W.P.A.*

The Filter Plant Comes First. G. E. HANDS & E. J. RUNYAN. Am. City, **65**:9:100 ('50). The new water treatment plant at LaFollette, Tenn., has 1-mgd capac. Proposed new reservoir described. Treatment comprises prelim. chlorination, coagulation with alum, sedimentation, and filtration through sand to remove the last traces of turbidity. Finally, lime added to adjust pH.—*W.P.A.*

New Filter Plant to Be World's Largest. F. C. GORDON. Am. City, **65**:7:69 ('50). Proposed Central Dist. filtration plant for Chicago will have a capac. of 950 mgd. Treatment provided will be same type as that now used at South Dist. plant and will include rapid mixing, flocculation, sedimentation, filtration, and chlorination; application of chemicals in liquid form will probably be used.—*W.P.A.*

SOFTENING AND IRON REMOVAL

Iron and Manganese Removal: Experiments at the New Brancepeth Water Treatment Works. W. GORDON CAREY & J. H. MAWSON. J. Inst. Wtr. Engrs. (Br.), **5**:306 (May '51). Examn. of water showed it was satisfactory bacterially but contained fairly high concn. of dissolved solids. Total hardness (all carbonate) is 252 ppm. Sequence of treatment first adopted was aeration by sprays, rapid gravity filtration, chlorination. Three filters, each 144 sq ft, produce 1 mgd (Imp.) at avg. flow rate of 100 gph per sq ft (Imp.). Soon after plant started, noticed that, with 1-ppm chlorine dose, there was no residual, and brown deposit of manganese dioxide formed on white glazed walls of inlet chamber of breakpressure tank. As temporary measure, while chlorination was continued, 3 ppm Calgon injected into water after aeration, but before filtration, to prevent deposition of manganese. Manganese and iron removal by pptn. ruled out, as plant not adapted to sedimentation. Manganese removal by base-exchange would involve dou-

(Continued on page 66)

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American Water Works Association
521 Fifth Avenue New York 17, N. Y.

(Continued from page 64)

ble treatment, as iron separates quickly and must be removed before passing through zeolite. Possibility of oxidation of manganese with ozone or chlorine then considered. Breakpoint of water at 3.5 ppm. Dosage of 5 ppm applied with 15-min contact before filtration. Treatment now used more than 1 yr is successful.—*H. E. Babbitt.*

Physicochemical Investigation of a Cation-Exchange Resin (Amberlite IR100). E. HEYMANN & I. J. O'DONNELL. J. Colloid Sci., **4**:395 ('49). I. Resin equilibria: Authors studied equil. between Amberlite IR100, a sulfonic acid resin, and salts of weak and strong acids. The limiting exchange (expressed as mg equiv. of acid liberated per g of air-dried resin), at high salt concn., was nearly same for all alk. metal chlorides and sulfates at low pH values. At higher pH values, limiting exchange was greater with salts of weak acids, indicating resin contained groups more weakly acid than sulfonic group, probably carboxylic and phenolic hydroxyl groups. Authors discuss the application of law of mass action to the equil. between resin and salts of strong acids. II. Resin conductance: Investigations made on elec. cond. of the resin contg. various bound cations. Hydrogen resin had low resistance, alk. metal resins had slightly higher resistances, and resins in which hydrogen was replaced by ions of higher valency or by silver were poor conductors. With hydrogen and alk. metal resins, cond. was approx. proportional to mobility of respective cations in water. Effect of pH value of salt soln. on the resistance of alk. metal resins studied. Max. resistance occurred at approx. pH 3.5 and decreased with increasing pH.—*W.P.A.*

Studies in Ion Exchange. Part I. Equilibrium Studies of Three Syn-

(Continued on page 68)

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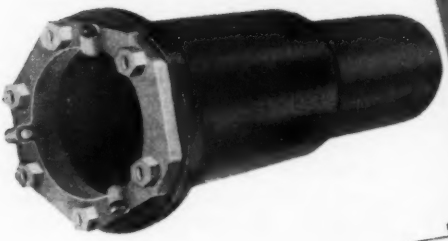

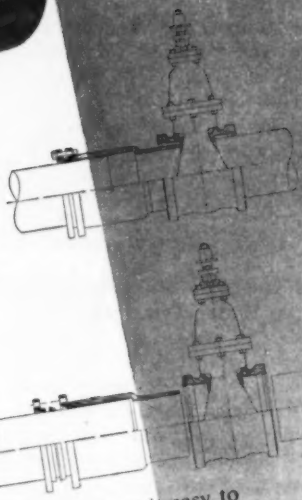

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(Continued from page 66)

thetic Cation-Exchange Resins. H. A. SHAH & S. L. BAFNA. Current Sci. (India), **20**:38 ('51). Results of equil. studies of the cation-exchange resins, Amberlites IR-100, IR-105, and IR-120, in the presence and absence of 20*N* sodium chloride indicated that, up to pH 10–10.5, active groups in resins are of sulfonic type; above pH 10.5, hydroxyl groups are also active. Excess cation increases cation uptake of resin at any given pH value. —*W.P.A.*

Monobed—Something New in Ion Exchange for Water Treatment. Power & Wks. Eng. (Br.), **54**:10:94 ('50). Development of mixed-bed method of ion exchange described.—*W.P.A.*

CHEMICAL FEEDING, CONDITIONING, AND SEDIMENTATION

Activated Silica as an Aid to Coagulation in Water Treatment Processes. H. J. WHEATON & J. G. WALKER. Chemistry & Industry (Br.), 710,802 ('50). Survey is made of use of activated silica for promoting coagulation in water treatment processes. Various methods outlined for the prepn. of activated silica sols from neutral sodium silicate using different activating reagents, including sulfuric acid, aluminium and iron salts, ammonium sulfate, chlorine, sodium bicarbonate, and sodium bisulfate. Results summarized of investigations on mechanism of coagulation aided by silica sol, including the effects of pH and temp. of water. Concluded that the action of the silica is dependent on the strong negative charge which it carries. Charts given for calcn. of the amt. necessary to effect optimum coagulation in a particular water and factors affecting the most satisfactory order of addn. of reagents discussed.. Found that max. removal of color from water is achieved if the sol is added after the coagulant, whereas greater turbidity removal achieved if sol is added first. Studies on effect of activated silica on coagulation with various reagents show that it increases flocculation speed with aluminium chloride and nitrate, copperas, and lime under the right conditions. Some acct. given of experience in Britain with large-scale use of activated silica in treatment of water, and of the factors to be considered in choosing which type sol to use in particular locality. Chief advantages and disadvantages of the process listed. Other uses of activated silica mentioned, including coagulation in sewage and in white waters from paper mills, and removal of oil from water. —*W.P.A.*

Reversion of Molecularly Dehydrated Sodium Phosphates. J. GREEN. Ind. Eng. Chem., **42**:1542 ('50). Molecularly dehydrated sodium phosphates used in treatment of water tend to react with water to form, finally, orthophosphate. Usually undesirable for reversion to proceed to completion, as presence of the orthophosphate reduces available dehydrated phosphate and may form insol. compds. of calcium or magnesium. Author studied reversion rate at 150 F and 190 F and at pH values of 5, 7, and 9, of seven molecularly dehydrated sodium phosphates. Formation rate of orthophosphate was taken as measure of stability of dehydrated phosphate. To 2 l of water at the required temp. and pH value and contg. 1700 ppm sodium chloride to give a constant ionic environment were added 5 ppm or 50 ppm phosphate. The pH value was readjusted if necessary. Samples of water were taken after 1, 3, 6, and 22.5 hr, and orthophosphate was detd. colorimetrically. Reversion rate generally greatest with 50 ppm phosphate at pH 5 and 190 F but was greatest

(Continued on page 70)

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(Continued from page 68)

with 5 ppm phosphate at pH 9 and 190 F. Stability of all phosphates tested increased with increasing pH value. Presence of calcium increased the reversion rate, increase being more rapid with increasing pH value. Presence of magnesium either did not affect the reversion rate or decreased it. Ppts. formed at pH 9 when calcium was present and, at pH 7, when magnesium was present. Sodium trimetaphosphate was more stable than other phosphates tested.—*W.P.A.*

Silica-Assisted Coagulation. J. L. BRYSON, G. EDWARDS, & A. W. TAYLOR. Chemistry & Industry (Br.), 626 ('50). In lab. tests made to det. whether use of activated silica would improve coagulation of water from the river Clyde, commercial water-glass was used to prepare silica sol; this has a ratio of SiO_2: Na_2O of 1:93, as compared with 3:22 in the commercial sodium silicate normally used. The commercial silicate forms a suitable sol if 85% of the alky. is neutralized, leaving a residual alky. of 1100–1350 ppm, but a solid gel forms in a few min when water-glass is neutralized to the same residual alky. Expts. showed neutralization to a residual alky. of 2000 ppm, equiv. to 84% neutralization, would prevent premature gelation with water-glass, and is concluded that proportion neutralization and not residual alky. is essential factor in prepg. a silica sol.—*W.P.A.*

On the Inhibiting Effect of Sodium Hexametaphosphate on Precipitation. I. Measurements on Barium Carbonate, Calcium Carbonate, Strontium Carbonate. L. CAVALLARO & A. INDELLI. Ann. Chim., Ferrara (Ital.), **40**:195 ('50). Authors studied inhibiting effect of glassy hexametaphosphate on the pptn. of alk. earths by sodium carbonate, using Brefon's method. Solns. of calcium chloride, strontium nitrate, or barium

(Continued on page 72)

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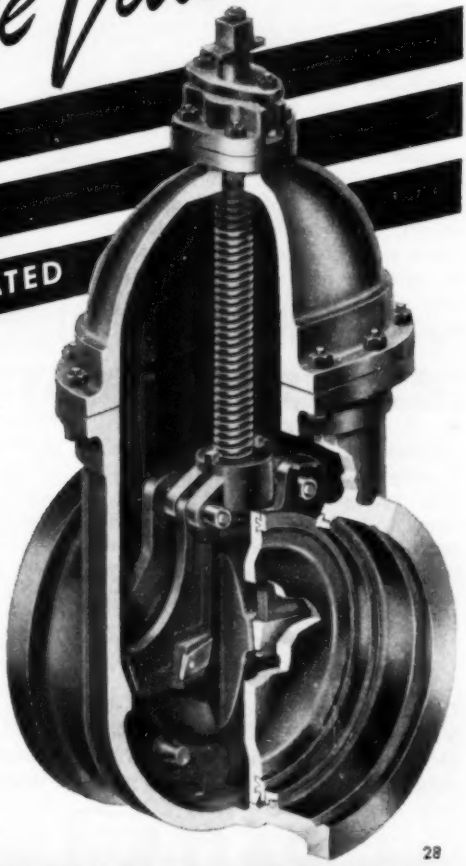

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(Continued from page 70)

chloride entered a soln. of sodium carbonate through a membrane and the relative conds. were detd. Amts. of carbonate obtained did not always agree with products of soly. and reasons for discrepancies are discussed. —*W.P.A.*

The Effect of Anion in Natural Waters on the Rate of Coagulation of Aluminum Hydroxide Sol. L. A. Koviski, A. M. Koganovski, & M. A. Chevchenko. Chimie & Industrie (Fr.), **65**:361 ('50). Expts. to det. effect of anions found in natural waters on rate of coagulation of an aluminium hydroxide sol have shown that eff. in accelerating coagulation increases in the order: chloride, hydroxyl, bicarbonate, and sulfate ions; and a more marked action is produced by mixture of ions than by simple ions. Ion excess does not retard coagulation.—*W.P.A.*

Hydrolysed Ferric Salt as Better Flocculating Agent. P. M. Barve & A. K. Jambotkar. Current Sci. (India), **20**:1:19 ('51). Ferric salts in soln. hydrolyze to yield a colloidal soln. of ferric hydroxide which is found to be more eff. for coagulating antimony sulfide sols than are unhydrolyzed salts. It is concluded iron is a better coagulant in colloidal state than in ionic.—*W.P.A.*

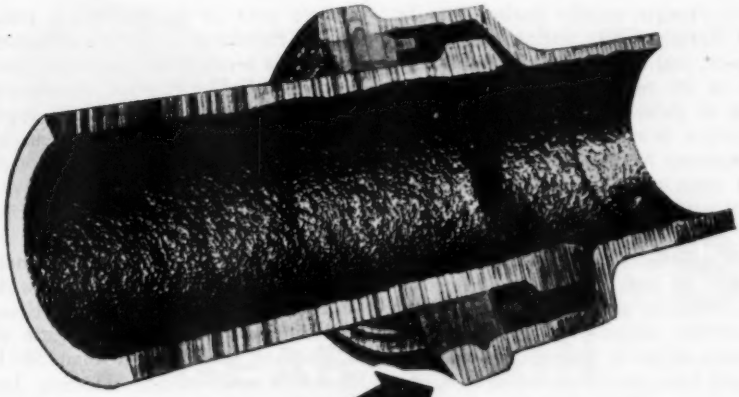
FLUORIDATION

Domestic Water and Dental Caries, VII. A Study of the Fluoride–Dental-Caries Relationship in an Adult Population. A. L. Russell. Pub. Health Rpts., **66**:1389 (Oct. 26, '51). Dental examns. given persons in 20–44-yr age group of verified histories of residence and water usage at Boulder, Colo., and Colorado Springs, Colo. Two groups comparable in race and occupation and cities similar, except water supply of Boulder is fluoride-free whereas Colorado Springs contains 2.5 ppm fluorides. Total rates for DMF permanent teeth approx. 60% less in Colorado Springs than in Boulder for each age group. Caries inhibition continued undiminished through the 44-yr group at Colorado Springs. Boulder natives had lost 3–4 times as many teeth from dental caries as had natives of Colorado Springs. Observed caries-inhibitory effect essentially similar in pattern and magnitude to that seen in children native to fluoride areas.—*F. J. Maier.*

Complex Fluorides: Caries Reduction and Fluorine Retention in the Bones and Teeth of White Rats. I. Zipkin & F. J. McClure. Pub. Health Rpts., **66**:1523 (Nov. 23, '51). Junior author previously reported similarity in availability of fluorine in NaF and Na_2SiF_6 by production of fluorosis. Present study sought data on availability of fluorine in several addnl. compds. as measured by: [1] deposition of fluorine in bones and teeth, [2] development of incisor striations, and [3] ability to inhibit caries. NaF, Na_2SiF_6, and Na_2PO_3F in drinking water (50 ppm F) reduced caries, deposited fluorine in bones and teeth and produced incisor striations, all to essentially same extent. By same measure, KPF_6 and CF_3COONa were physiologically inert. None of these fluorides had any cariostatic effect when administered by injection.—*F. J. Maier.*

Determination of the Fluoride Ion With Ferric Thiocyanate. R. S. Ingols, E. H. Shaw, W. H. Eberhardt, & J. C. Hildebrand. Anal. Chem., **22**:799 ('50). Technique recommended in *Standard Methods* for detg. fluorine in potable waters, using zirconium-alizarin lake, has three disadvantages. Hue changes with increases in the fluoride content, the

(Continued on page 74)



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color changes rapidly during first hr and reproducibility during this period is poor, and results are affected by the age of the reagents. Method having none of these disadvantages based on reduction in color of a soln. of ferric thiocyanate by fluorine ions. As certain ions, such as iron and sulfate, often present in natural waters interfere with detn., an investigation was made of effects of pH value, relative concns. of iron and thiocyanate ions, and of sulfate and total ion concns. on sensitivity towards 1 ppm fluoride. Concns. of ferric, thiocyanate, and hydrogen ions can be controlled by amts. of chems. added. Colorimetric comparisons are made of three tubes, one contg. sample and reagents; one, distilled water and reagents; and one, sample, reagents, and zirconyl oxychloride. Tube with distd. water may not be necessary if concns. of sulfate ion and total salt are known. Addn. of zirconyl oxychloride partly restores color of ferric thiocyanate by reacting with the fluoride more strongly than does ferric ion. Increase in color intensity effected by addn. of zirconyl ion is, therefore, measure of concn. of fluoride ion. Difference in color between tube contg. distd. water and reagents and that contg. zirconyl oxychloride as well as sample and reagents is due mainly to sulfates. Full color developed at once and is stable in the dark for several hr although sensitive to blue light. Results reproducible, and sensitivity similar to that of zirconium-alizarin technique.—*W.P.A.*

An Improved Micro-Method for the Determination of Fluorine Based on an Examination of the Fluoride-Fluosilicate Equilibrium. J. B. Rickson. Analyst (Br.), **75**:84 ('50). Study of fluoride-fluosilicate equil. system has shown that low results obtained in the microdetn. of fluorine by titration with thorium nitrate may be because some of the fluorine is present as fluosilicate. Before titration, fluoride is sepd. from interfering ions by distn. Unlike fluorine, fluosilicate ion does not form an unionized compd. with thorium nitrate. Error can be overcome and 20–400 μg. of fluorine can be estd. with an accuracy of 1–5% if the titration is carried out in a 50% alc. soln., buffered at pH 5.3 using gallocyanine as indicator. Procedure described. Chloride in concns. of less than 1 mg per 10 ml does not interfere when the ratio of chlorine to fluorine less than 50:1. Phosphate and sulfate interfere but are removed in the prelim. distn. Effect of varying pH during titration described. Method has been applied to soil anal.—*W.P.A.*

Photofluorometric Titration of Fluoride. H. H. Willard & C. A. Horton. Anal. Chem., **22**:1194 ('50). Procedure described for photofluorometric detn. of fluorine in presence of considerable sodium chloride by titration with thorium nitrate using quercetin as fluorescent indicator. Factors affecting titration discussed include type and concn. of alc. used, concn. of indicator, pH and temperature variations, effect of stirring, and interfering ions. Method may be used for org. compds. after alk. decompn. or after the Willard-Winter sepn. Results obtained are more accurate than those obtained visually using Alizarin Red S as indicator.—*W.P.A.*

Rapid Test for Fluoride Ion. W. R. Crandall. Anal. Chem., **22**:1449 ('50). In prepn. of casein solns. for industrial purposes, sodium fluoride may be used to decompose calcium compds. present in commercial casein. Test described which is used to control fluoride excess used for this purpose. Slip of paper dipped in indicator dried and laid on glass surface, and across it is placed slip of dry

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paper impregnated with aluminium acetate. The pH of sample adjusted to within the middle or lower part of the range of the indicator chosen, and drop of sample placed on the intersection of the two slips. Addn. of 1 drop of soln. contg. 0.01%, or more, sodium fluoride causes a perceptible change of color. Methyl red, bromocresol purple, bromothymol blue, and thymol blue are suitable indicators. Interference by anions discussed.—*W.P.A.*

What Do You Know About Fluoridation of Water Supplies? H. F. MUNROE. Pub. Wks., **81**:9:39 ('50). Various problems associated with the addn. of fluorides to water supplies discussed, including the effect of fluorides in various concns. on teeth and bones, procedure for adding fluorides to water, detn. of fluoride and effect of chlorine on its detn. and the effect on the silica content of water of adding fluorine as sodium silico fluoride. —*W.P.A.*

STREAM POLLUTION CONTROL

Cemeteries as Sources of Water Pollution. F. W. J. VAN HAAREN. Water (Neth.), **35**:167 (Aug. 2, '51). In sandy soil approx. 10 yr is required to oxidize a corpse. During decompn., breakdown products leach out. Results of anals. of surface and ground waters of a number of cemeteries show that, in all, waters were heavily pold.—*W. Rudolfs.*

Treatment With Chlorine of Industrial Wastes. A. E. GRIFFIN. Eng. & Contract Rec. (Br.), **63**:11:74;80 ('50). Discusses use of chlorine for treating waste waters from various industries. When waste waters contg. cyanide are treated with approx. 8 parts chlorine to 1 part cyanide and sufficient caustic soda to give a pH

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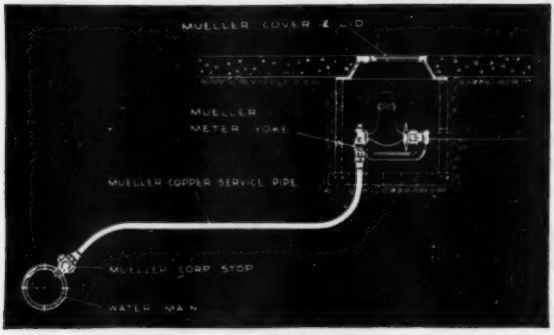

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value of 8.5–10.0, cyanide is completely oxidized. Phenol can be removed from waste waters by chlorination at pH 7.0–10.0; as phenol waste waters usually contain considerable org. matter, 100–200 parts chlorine may be required per part phenol; treatment should be followed by dechlorination. After chem. or biol. treatment of waste waters from canning industry, it may be necessary to treat effluents with chlorine; chlorination to give a residual content of 0.5 ppm free chlorine removes approx. 30% of unstable org. matter present in the effluent and reduces growth of fungi in receiving stream. Waste waters from slaughter houses and from processing of fish have high contents of protein and both are amenable to treatment with chlorine and lime; procedure developed by R. R. Kountz and W. E. Link for treatment of slaughter-house wastes described. Waste waters from wool scouring can be treated satisfactorily by applying chlorine as calcium hypochlorite. Color and BOD of waste waters contd. dyes can be substantially reduced by chlorination; use of a coagulant reduces amt. of chlorine required by approx. 50%. Waste waters from beet-sugar factories have high BOD and high content of suspended solids. After treatment with lime to give pH 6.5–7.0 and chlorine to give residual content of 5 ppm free chlorine, supernatant liquor from settled wastes can be reused as process water. Reduces amt. of water required for diffusion by approx. 33%.—*W.P.A.*

Some Economic Factors in Waste-Water Treatment. V. J. CALISE. Chem. Eng. Progress, **46**:328 ('50). Economic factors affecting selection and operation of plants for industrial waste-water treatment discussed. Simple plant described for neutralization at const. rate of acid waste waters from small metal-plating plants. Lime is added dry, and hypochlorite may be used to oxidize traces of cyanide; caustic soda may be substituted for lime where more convenient. Up-flow calcite filter can be used to neutralize small amts. of settled acid waste waters. A proportioning plant for use where vol. of waste water varies considerably described; amount of lime added is controlled by pH value of water. Some alk. waste waters may be used to neutralize acid wastes. Treatment plant for use where there are high concns. of objectionable impurities comprises primary and secondary clarification units, and a coagulant and a coagulant aid, such as activated silica, are used. Large quants. of fiber and filler are lost in the waste waters from pulp and paper mills, because it is difficult to settle the suspended solids. A solids contact reclaimer described which will reduce the concn. of stock in water to less than 0.25 lb per mil gal. Simplified version of plant may be used in small works. Installation described for removal of oil from waste waters from an oil refinery by addn. of alum and filtration through Anthrafilt. Approx. 300 gpm of clarified water are dischgd. to waste and 1200 gpm reused in refinery. In discussion, an acct. given of economic problems of treating acid waste waters from mines in western Pennsylvania.—*W.P.A.*

Treating Tank-Car Wastes. G. GUTZEIT. Chem. Eng. Progress, **46**:335 ('50). Methods of cleaning tank-cars described, and tables given showing quant. and compn. of wastes from two large tank-car maint. shops. Proposed treatment plant for waste waters from a new maint. shop described, and flow diagram given. Cars will be divided into three categories according to: whether their last load consisted of products which are solid at ordinary temps. or aq. suspensions of such solids; liq. immiscible with water; or sol. materials; or compressed gases. Combusti-

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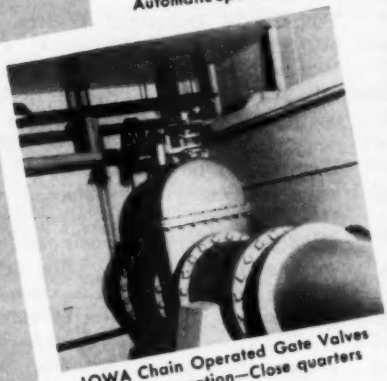

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ble solids will be incinerated and incombustibles, such as clay and sand, will be dumped. Wash waters from cars used to store acids and liq. immiscible with water will be passed through mechanical oil separators, powdered coal will be added to adsorb hydrophobic compds., and then separated by froth flotation. Process applicable to treatment of waste waters contg. phenols and to removal of hydrophobic liq. from emulsions, but its application may be limited by the amt. of coal needed. All other waste waters will be aerated and coagulated with ferrous sulfate and lime. The effluent will flow to a lagoon and then pass through percolating filters, together with sanitary sewage from the works, before sedimentation and dischg. Tables given showing the results of treating raw wastes by this method in other works; in only one, is segregation practiced, and here the results are excellent. Expected that 85% of BOD will be removed, and content of phenol will be reduced to less than 1 ppm. In reply to discussion, author stated that high concns. of inorg. ions reduce capac. of coal to adsorb phenol and other org. compds.—*W.P.A.*

Pollution of Water. Biological Analysis. M. HUET. Bull. Centre Belge et Documents Eaux, No. 5; p. 259; No. 6, p. 346. Discusses poln. of water by dissolved and suspended material; effects of poln. on aquatic flora and fauna, particularly on fish; and physicochem. and biol. examn. of pold. water. Interpretation of results of biol. examn., used to supplement chem. anal., based on fact that various types of poln. stimulate growth of characteristic flora and fauna. Organisms which commonly occur in heavily pold., lightly pold., and relatively unpold. water described and illustrated. Methods used in treatment of waste waters before dischg. to surface waters are reviewed, including screening, sedimentation, biol. filtration, the activated-sludge process, sludge digestion, treatment on land, and disinfection. Diagrams and photos of plant units given.—*W.P.A.*

The Control of River Pollution in the Future. W. SAVAGE. London Sanitarian, **58**:431 ('50). The River Boards Act, 1948, discussed with special reference to the changed position of local authorities in the prevention of river poln. and to report of the Rivers Pollution Prevention Subcommittee. Suggests local authorities can cooperate with new boards in detg. stds. for polg. effluents, in admitting trade waste waters into municipal sewers, in surveying streams, and in collection of samples.—*W.P.A.*

Toxicity of Industrial Wastes. R. W. STONE, A. D. BRADFORD, & F. WEBER. Proc. Am. Petroleum Inst., III., **30M**:160 ('50). Studies made of use of bacteria as test organisms for detg. toxicity of trade waste waters. Bact. examn. of pold. and unpold. waters in Pennsylvania showed that Gram-negative rods of *Achromobacter, Alcaligenes, Flavobacterium,* and *Pseudomonas* predominated. Little difference in types occurring in clean and pold. waters. Sensitivity of cultures of these types and of coliform bacteria investigated by various methods. Most satisfactory results obtained by growth-inhibition test, in which highest concn. of substance being tested which would allow growth detd. Visual turbidity in nutrient broth used as growth indicator. Sensitivity of bacteria to toxic chems. was compared with that of fish. Found that, although fish and bacteria tolerate similar range of pH values, fish more sensitive to most toxic substances. Test described for detg. toxicity of waste waters by adding known dilns. to cultures of *Achro-*

(*Continued on page 82*)

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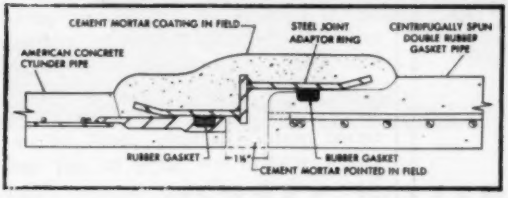

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(*Continued from page 80*)

mobacter, Alcaligenes, Flavobacterium, Micrococcus, and *Pseudomonas.*—*W.P.A.*

Fish As Indicators of Stream Pollution. R. CZENSNY. Vom Wasser (Ger.), 17:16 ('49). Dealing with effect of poln. on fish and use of fish as indicators of poln., first defines a clean stream as one in which natural fish fauna is able to live and breed, compn. of natural flora and small animals on which fish feed have not been changed or their density diminished, and nothing interferes with operations involved in fishing. Effects of different types of poln. on fish themselves, on fish food, and on fisheries discussed. Concluded that, in general, absence of fish typical of stream can be taken to indicate poln.—*W.P.A.*

Fish As Carriers of Bacteria. G. BRUNNER. Vom Wasser (Ger.), 17:9 ('49). Fish may carry pathogenic bacteria either externally or internally. Bacteria on skins of many fish may cause erysipelas on hands of persons working with fish. Infection enters through small wounds and likely to be caused by fish, such as perch, which have sharp spines on fins. Not known how sea fish become infected with these bacteria. Fish may also act as carriers of typhoid and paratyphoid. Fish is frequently infected after death, but expts. described show that, when fish ate food infected by Gärtner bacteria or were kept in infected water, bacteria could be detected within few days in gut and later in flesh and other organs. After initial infection, several wk required for disappearance of bacteria. Even after 7–9 wk in fish, bacteria do not lose pathogenicity to man. Usual methods of preparing and cooking fish cannot be relied on to kill all pathogenic bacteria. Except where bacteria are in fish flesh, danger of

(*Continued on page 84*)

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(*Continued from page 82*)

infection can be reduced by cleaning fish immediately it is caught and preventing any contact between the flesh and the contents of the gut. Danger of infection of fish is greatest where poln. of water by industrial waste weakens resistance of fish to bacteria, rather than where fish are grown in sewage works effluent.—*W.P.A.*

Minimum Requirements for the Control of Industrial Wastes. Washington State Pollution Control Commission. Sew. & Ind. Wastes, **22**:514 ('50). Min. requirements for the disposal of trade waste waters to prevent poln. of surface waters in Wash. have been laid down by the poln. control commission. Trade waste waters dealt with include those from slaughter houses and meat-packing plants, poultry killing and packing plants, milk and milk products plants, vegetable, fruit, fish, and shellfish canneries, wineries, breweries, sawmills, tanneries, beet-sugar factories, coal and gravel washeries, processing of flax, dehydration of potatoes and fruit, metal industry, and pulp and paper mills, and those contg. oil.—*W.P.A.*

Report of the Rivers Pollution Prevention Sub-Committee of the Central Advisory Water Committee. S. R. Hobday & B. A. Southgate. J. Br. W.W. Assn. (Br.), **32**:243 ('50). At 1950 annual meeting of the association, legal and technical aspects of recommendations in report of subcommittee of the central advisory committee were discussed with reference to powers of river boards. Subjects dealt with included the setting up of stds. for effluents, control of new openings for drains and sewers into streams, content of solids in effluents, temp. and color of effluents, poln. of tidal waters, and development of tests for qual. of industrial effluents.—*W.P.A.*

Radioactive Sewage. Discovery (Br.), **11**:186. Illustrations given of waste water treatment plant of atomic energy research establishment at Harwell. Plant comprises primary sedimentation tanks operated in series, tanks where sodium carbonate is added to ppt. radioactive materials, such as radioiron, as insol. carbonates, and secondary sedimentation tanks from which the radioactive sludge is drawn off for storage in lead barrels; ultimate disposal of this sludge an unsolved problem. Effluent dischgd. to Thames at rate of 250,000 gpd. Mud and water below dischg. point tested for radiation.—*W.P.A.*

Industrial Stream Pollution Abatement. L. L. Hedgepeth. Proc. Am. Soc. Civ. Engrs., **76** ('50). Emphasizes that, to control stream poln. by trade waste waters, every case must be considered individually and that state authorities and industrial owners should cooperate to reduce poln. Examples given of procedures used by the Virginia State Water Control Board to investigate and control poln. caused by waste waters from a sulfate pulp mill, a wool scouring and finishing mill, and a rayon finishing and dyeing plant.—*W.P.A.*

Solving the Problem of Purification of Trade Waste Waters. M. Reignier. Tech. Eau (Belg.), **4**:42:7 ('50). Discusses harmful effects to both streams and industries of phys., chem., and biol. poln., and of increases in temp. caused by dischg. of hot waste waters, and reviews methods of anal. to det. extent of poln. Methods of treating trade waste waters discussed in general and examples given of treatment of waste waters from metal works, glass works, and metal pickling in the basin of Sambre, from wool scouring in basin of Vesdre and Espierre, and from paper mills. As far

(*Continued on page 86*)

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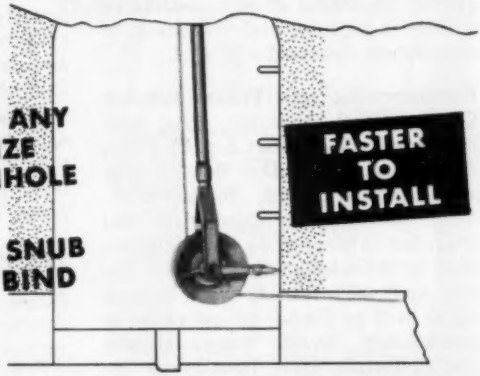

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(*Continued from page 84*)

as possible, waste waters should be treated to recover materials and should then be reused.—*W.P.A.*

Four Ways to Economize on Industrial Wastes. R. W. SIMPSON. Sew. & Ind. Wastes Eng., **21**:357;379 ('50). Industrial waste waters may be classified into four types according to their effect on surface waters: acidic or basic waste waters, org. waste waters which cause oxygen deficiency, waters contg. oils and greases, and waters contg. inert material which causes silting. Four main steps to combat poln. suggested. Vol. of waste can be reduced by using min. of raw water in plant. Improvements in processing methods may lead to reduction of waste. In many industries byproducts can be recovered; some examples given. Treatment of waste waters by storage in lagoons, biol. treatment, or coagulation discussed.—*W.P.A.*

Fundamentals of Trade Effluent Control. S. L. WRIGHT. Proc. Inst. Sew. Purif. (Br.), Part 2, p. 85 ('50). At Oxford, dry-weather flow of sewage is approx. 5 mgd. Present treatment comprises sedimentation and irrig. but is planned to provide treatment by activated-sludge process. Nature and vol. of trade waste waters which will be dischd. to sewers being investigated. Waste waters already studied include those from motor industry, dairies, laundries, brewing, food processing, and gas works. Estd. that 17.1% of total vol. of sewage, 6.54% of BOD load, and 31.84% of load expressed as oxygen absorption, is due to trade waste waters. Author considers that most eff. control of the dischg. of trade waste waters to sewers can be achieved by private agreements between municipal authorities and manufacturers. Methods of treating waste waters before dischg. to sewers briefly outlined.—*W.P.A.*

The Problem of Waste Waters. E. W. STEEL. Tech. Eau (Belg.), **4**: 45:19 ('50). Problem of controlling poln. of rivers by industrial waste waters discussed with special reference to conditions in the U.S. and to the work of the U.S. Pub. Health Service.—*W.P.A.*

Fish Toxicology. M. HUET. Bul. Centre Belge et Documents Eaux (Belg.), No. 7, p. 369 ('50). Various ways described in which toxic substances may affect fish physiologically. Methods used in detg. toxicity, factors affecting results of tests on toxicity, and symbols for use in expressing results discussed, and, based on published data, toxicity of some commonly occurring substances given. Substances include mineral and org. acids, water of high alky., iron, manganese, copper, zinc, lead, structural materials such as concrete, sodium and calcium chlorides, ammonia, chlorine, arsenic, artificial fertilizers, products from the distn. of tar and petrol such as benzene, phenols, cresol, pyridine, and cyanides, naphthalene, nicotine, natural resins, pyrethrum, derris, saponins, picrotoxin, and substances secreted by mollusks.—*W.P.A.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

Water Analysis. S. K. LOVE. Anal. Chem., **23**: 253 ('51).

Corrosion and Passivation of Mild Steel at High Speeds of Movement in Aqueous Solutions. F. WORMWELL & H. C. K. ISON. Chem. Chemistry & Industry, p. 459 ('50).

Colorimentric Determination of Copper With Pyridine and Salicylic Acid. V. A. GORDIEYEFF. Anal. Chem., **22**: 1166 ('50).

Micromethod for Estimation of Potassium by Paper Chromatography. E. BEERSTECHER. Anal. Chem., **22**: 1200 ('50).

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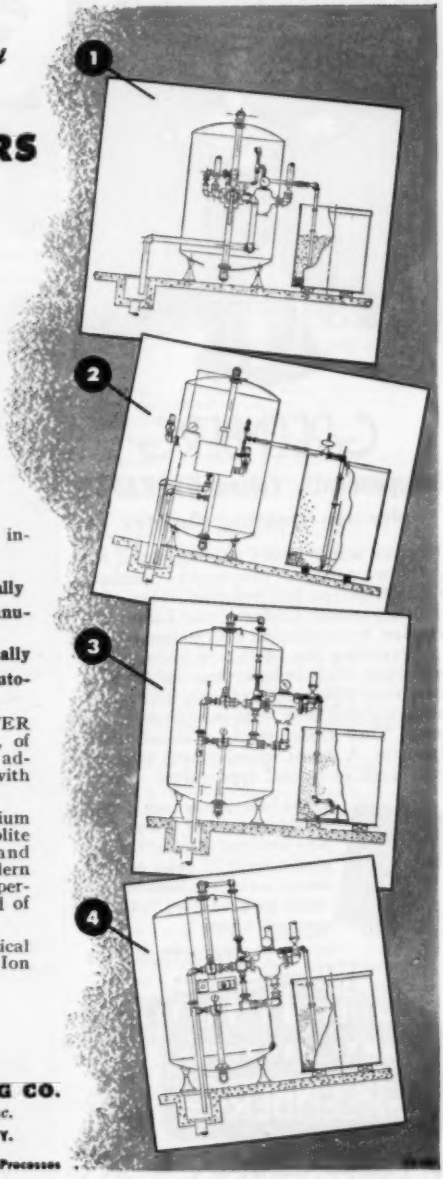

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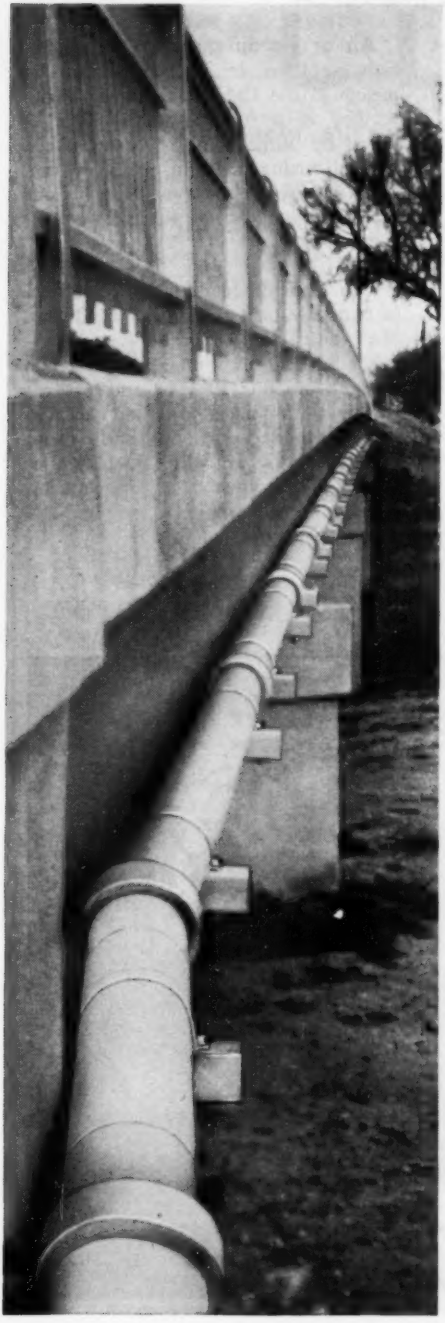
A new radiation monitor designed to detect and record gamma rays in an area, sounding an alarm when average tolerance limits are exceeded, has been produced by General Electric Co., Schenectady 5, N.Y. It is described in a leaflet, GEC-827, which is available on request.

Quaternary ammonium disinfectant Hyamine 2398, produced by Rohm & Haas Co., Washington Square, Philadelphia 5, Pa., is the subject of a new technical bulletin available from the company. Data on bactericidal efficiency in waters of various hardness are included.

A pH indicator and vacuum tube voltmeter developed by Leeds & Northrop, 4934 Stenton Ave., Philadelphia 44, Pa., which is said to be unaffected by fluctuations in line voltage or zero drift of the amplifier, is the subject of a bulletin which is available on request.

Totally enclosed, fan-cooled motors (TEFC) produced by Allis-Chalmers Mfg. Co. are described in a bulletin, 51B7149B, available on request to the company at 1026 S. 70th St., Milwaukee, Wis.

(*Continued on page 90*)



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(Continued from page 88)

Protective coatings for metals are the subject of a 24-page booklet available from Reilly Tar & Chemical Corp., 1615 Merchants Bank Bldg., Indianapolis, Ind. Properties of various hot and cold application enamels, primers and bituminous paints, application procedures and amounts, and containers and storage methods—all are described and discussed.

Leakproof tube fittings for instrumentation and process lines are cataloged in a 12-page bulletin, B–151, distributed by Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio. The Swagelok fittings feature tight joints, ease of assembly, and avoidance of damage to the tubing during installation.

Air or gas diffusion for recarbonation, aeration, or air flocculation by means of the Colaflex Diffuser is described in a folder, Bul. 6530, prepared by Infilco, Inc., Tucson, Ariz. The diffusing element is a woven, seamless plastic fabric made in various materials and weaves to suit working conditions.

Dry fluoride feeding is the subject of two new bulletins issued by Omega Machine Co., 345 Harris Ave., Providence 1, R.I. A volumetric model is described in Bul. 50–H14, and features a dust-minimizing hopper that can hold two 100-lb bags or one 125-lb drum of chemical. Bulletin 30–H21 describes a gravimetric model operating on the loss-of-weight principle to a high degree of accuracy.

(Continued on page 92)

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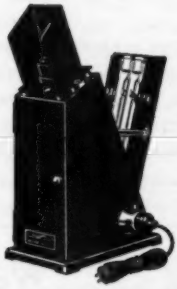

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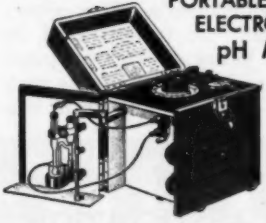

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(Continued from page 90)

Colorimeter accessories are featured in the revised edition of the Photovolt Corp. bulletin, No. 420, on the Lumetron Photoelectric Colorimeter Model 402-E. Copies may be obtained upon request from the company, at 95 Madison Ave., New York 16, N.Y.

The new 135-page, clothbound catalog of M&H valves, hydrants and accessories has just been issued. In addition to furnishing complete information about M&H products, the handsomely illustrated book also includes a lengthy section devoted to engineering data, including material taken from various pipe specifications, tables of conversion factors, and trigonometric functions. Requests for Catalog 52 should be sent, on business stationery, to M&H Valve & Fittings Co., Anniston, Ala.

Emergency ventilation can be afforded by a device that employs the pressure of compressed air or steam to induce movement of approximately ten times its volume of air. Known as the M.S.A.-Lamb Air-Mover, the device is described in a folder available from Mine Safety Appliances Co., Pittsburgh 8, Pa.

"Liquid Chlorine," the third edition of the Solvay manual, has just been issued and is available without cost to readers in the U.S. and Canada. The 57-page booklet contains information on the properties of chlorine, transportation equipment for it, and its safe handling. Requests for Bul. 7 should be sent to Solvay Sales Div., Allied Dye & Chemical Corp., Advertising & Sales Promotion Dept., 40 Rector St., New York 6, N.Y.

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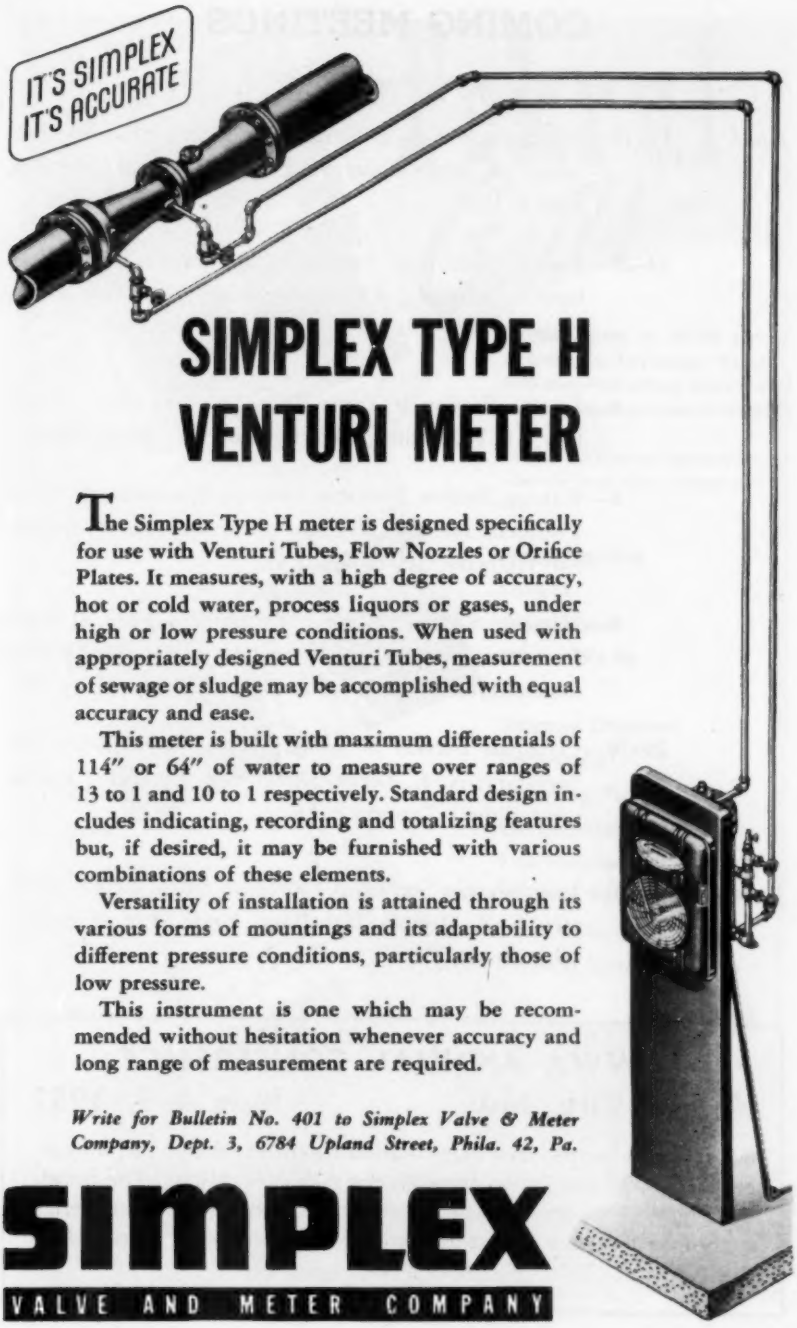

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COMING MEETINGS

(*Continued from page viii*)

April **17–18**—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary: E. Bruce Meier, Asst. Prof., Univ. of Nebraska, Lincoln.

24–26—Pacific Northwest Section at Davenport Hotel, Spokane. Secretary, O. P. Newman, Box 548, Boise, Idaho.

May **3**—Kansas Section at Town House, Kansas City. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

6—Kansas Section Business Meeting Luncheon at Hotel President, Kansas City, Mo. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

6—Missouri Section Business Meeting Luncheon, at Hotel President, Kansas City. Secretary, W. A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

26–28—Canadian Section at Mount Royal Hotel, Montreal. Secretary, A. E. Berry, Director of San Eng., Parliament Bldgs., Toronto 2, Ont.

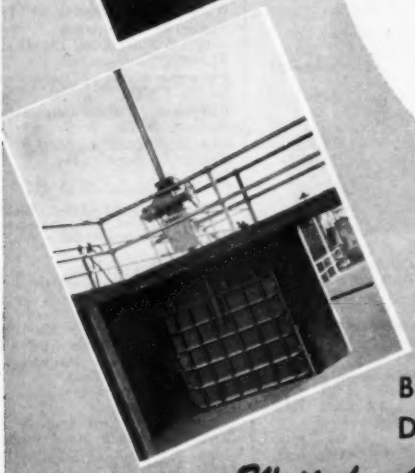
June **18–20**—Pennsylvania Section at Lawrence Hotel, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

AWWA ANNUAL CONFERENCE

Kansas City, Mo. May 4–9, 1952

Reservation forms have been mailed to all members, and all reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the AWWA.

Pekrul Gates



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Write for Catalog 49

Index of Advertisers' Products

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Industrial Chemical Sales Div.
Permutit Co.

Aerators (Air Diffusers):
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Infilco Inc.
Permutit Co.

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Worthington Pump & Mach. Corp.

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General Chemical Div.

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Proportioneers, Inc.

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Cochrane Corp.
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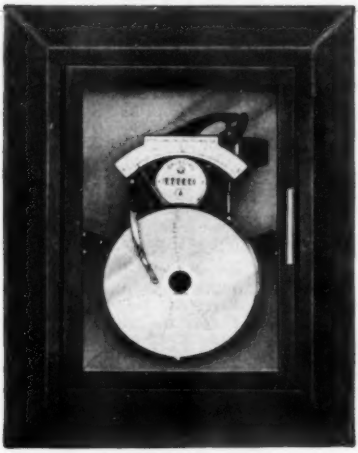

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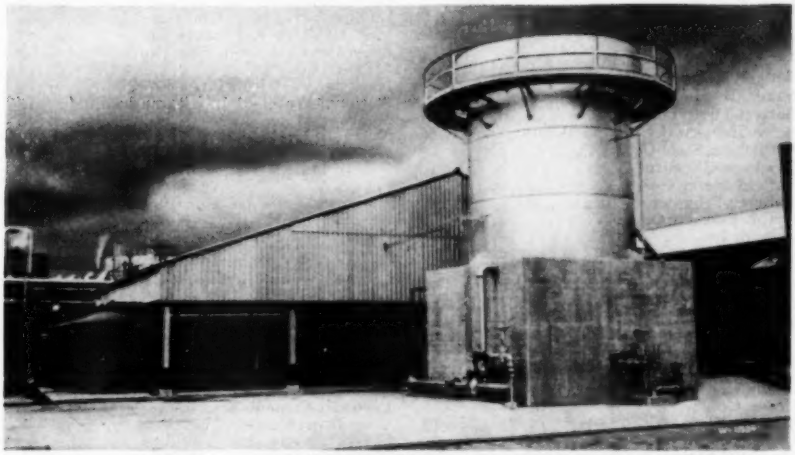

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Specially Designed for Intermittent Service

Softening system for boiler feed water built for short-period operation, long shutdowns

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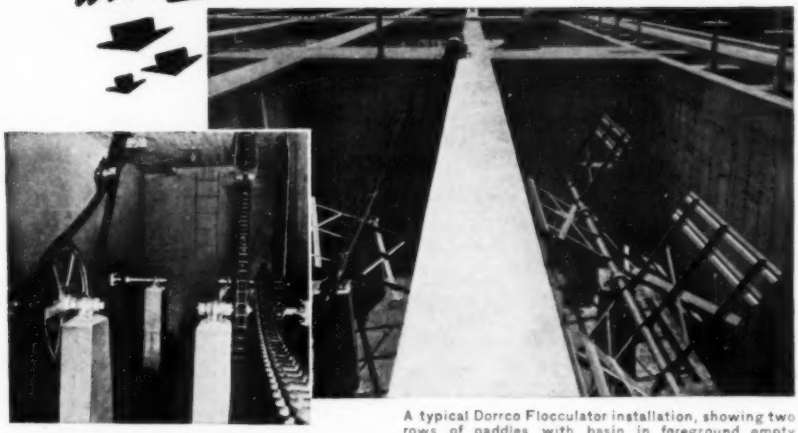

Closeup of Dorrco Flocculator drive mechanism showing completely enclosed dry well

A typical Dorrco Flocculator installation, showing two rows of paddles with basin in foreground empty

That's the actual case history of a Dorrco Flocculator installation at a large Eastern water treatment plant. The water works superintendent reports absolutely no trouble with bearings, paddles, or drive mechanism since this unit was first installed in 1939 at a design capacity of 10 M.G.D. This is typical of the operating dependability you get with Dorrco Flocculators. The dry well feature means that the entire drive mechanism is never exposed to water and is readily accessible at all times.

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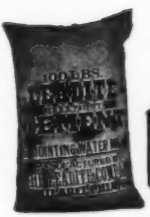

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